BIOLOGICAL RHYTHMS
IMPLICATIONS FOR THE WORKER

NEW DEVELOPMENTS
IN NEUROSCIENCE

J952-75

CONGRESS OF THE UNITED STATES OFFICE OF TECHNOLOGY ASSESSMENT

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Foreword

Approximately 20 million Americans work some form of nonstandard work schedule. These schedules, which require that an individual work during nondaytime hours, noncontinuous hours, or for extended periods, are referred to as "shift work." Recent advances in the understanding of the biological rhythms of the body and their control by the brain indicate that shift work can disrupt these rhythms, with possible adverse consequences for the worker.

This report is the third in a series of OTA studies being conducted under an assessment of "New Developments in Neuroscience." It was requested by the House Committees on Appropriations; Energy and Commerce; Science, Space, and Technology; Veterans Affairs; and the Senate Subcommittee on Science, Technology, and Space of the Committee on Commerce, Science, and Transportation. The report discusses biological rhythms: what they are, how they are controlled by the brain, and the role they play in regulating physiological and cognitive functions. The major focus of the report is the examination of the effects of nonstandard work hours on biological rhythms and how these effects can interact with other factors to affect the health, performance, and safety of workers.

In addition, the report describes the Federal regulatory framework related to work hours and the current status of biological rhythm and shift work research. The report presents a range of options for congressional action related to the amount of research being conducted on these topics, the collection of relevant workplace statistical data, and the congressional role in ensuring the well-being of individuals engaged in nonstandard hours of work.

The first publication in OTA's assessment of "New Developments in Neuroscience" was *Neurotoxicity: Identifying and Controlling Poisons of the Nervous System*, published in April 1990, and the second was *Neural Grafting: Repairing the Brain and Spinal Cord*, which was published in September 1990. OTA was assisted in preparing this study by a panel of advisers, a workshop group, and reviewers selected for their expertise and diverse points of view on the issues covered by the assessment. OTA gratefully acknowledges the contribution of each of these individuals. As with all OTA reports, responsibility for the content of this report is OTA's alone. The report does not necessarily constitute the consensus or endorsement of the advisory panel, the workshop group, the reviewers, or the Technology Assessment Board.

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NOTE: OTA appreciates and is grateful for the valuable assistance and thoughtful critiques provided by the advisory and study panel members. The panels do not, however, necessarily approve, disapprove, or endorse this background paper. OTA assumes full responsibility for the report and the accuracy of its contents.

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Chapter 1

Summary, Policy Issues, and Options for Congressional Action

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Chapter 1
Summary, Policy Issues, and Options for Congressional Action

Biological rhythms are changes in various physiological and behavioral functions of organisms that repeat at regular intervals and provide a framework of temporal organization for them. Biological rhythms in humans have cycles ranging from minutes to months; for example, stages of sleep and the release of a number of hormones in the body cycle with a rhythm measured in minutes, while the female menstrual cycle is measured in days (box 1-A). **Cycles in synchrony with the 24-hour rotation of the Earth are probably the most widely studied.** External factors that disturb the internal clock can produce deleterious effects. A common example is jet lag, the malaise associated with travel across time zones. In the case of jet lag, the effect is short-lived and the body readjusts relatively quickly to the local time at the new location. **Work schedules outside the standard daytime hours can disrupt the biological rhythms of the body. This disturbance can continue unabated while other factors, such as sleep loss and social disruption, compound the deleterious effects. The results can be detrimental to some workers' health and ability to perform their jobs, which in turn can adversely affect their safety and that of society as a whole.**

The term "shift work" is often applied to schedules that include nondaytime hours of work, but there is no consistent definition of the term. As **used in this report, shift work refers to any nonstandard work schedule. It includes evening** or night work; a rotating shift, in which hours change regularly (e.g., from day to evening to night); a split shift, in which a period of work is followed by a break and then a return to work; and **extended duty hours**, consisting of long periods of work (usually over 12 hours). **This report focuses on the impact these schedules can have on the body's biological rhythms.**

Diverse occupations require or involve 24-hour operations and use nonstandard work schedules. They include manufacturing industries (e.g., chemical, steel, paper), utilities (e.g., powerplants), protec-

Box 1-A—Biorhythms Are Not *Biological Rhythms*

The scientific study of the biological rhythms of the body should not be confused with the theory of biorhythms. No evidence exists to support the concept of biorhythms; in fact, scientific data refute their existence. Based on a theory first proposed by the German scientist Wilhelm Fliess in 1897 and popularized in the 1970s, biorhythm theory postulates that three cycles act in a concerted fashion to guide activity: a 23-day cycle that influences physical strength, endurance, energy, and physical confidence; a 28-day cycle that influences feelings, love, cooperation, and irritability; and a 33-day intellectual cycle that influences learning, memory, and creativity. According to biorhythm theory, these three cycles are linked to an individual's birth date and fluctuate in a constant fashion throughout his or her life. Each cycle has a high and a low point. By mapping the high and low points of the respective cycles and how they coincide or diverge, the theory states, performance can be charted, and critical days when performance can be expected to be highest or lowest can be predicted.

Although a theory that provides a system for predicting human behavior and scheduling activities has appeal, none of the contentions of biorhythm theory can be supported. No biological process with such a relationship to the calendar date of birth has ever been identified, nor have any studies attempting to validate biorhythms been able to do so. Thus, for example, attempts to validate the hypotheses using retrospective airplane crash reports and athletic scores have consistently failed. While there clearly are human biological rhythms with cycles that can be measured in days (the menstrual cycle being an example), there is no evidence for the existence of any of the three biorhythms, let alone any predictive interaction. Given its nonfactual basis, biorhythm theory is relegated to the realm of other popular pastimes, such as numerology, that can serve as a source of entertainment but have no substantive or predictive value.

SOURCE: D.C. Holley, C.M. Winget, C.M. DeRoshia, et al., *Effects of Circadian Rhythm Phase Alteration on Physiological and Psychological Variables: Implications to Pilot Performance (Including a Partially Annotated Bibliography)*, NASA technical memorandum TM-81277 (Moffet Field, CA: National Aeronautics and Space Administration, March 1981).

tive and health services (e.g., police, fire and rescue, hospitals), transportation (e.g., airlines, railroads, trucking, shipping), major construction projects (e.g., dams, tunnels), military operations, and, increasingly, services (e.g., retail stores, financial institutions, entertainment and recreation, specialized services such as overnight deliveries).

At the Federal level, the Fair Labor Standards Act, which was enacted in 1938, established a standard 40-hour workweek. Various hours of service acts regulate maximum hours for a number of industries, notably transportation. Some States regulate hours of work, and collective bargaining agreements can specify hours and shift schedules.

The Federal Government has authority to regulate working conditions that endanger the safety and health of workers through the Occupational Safety and Health Administration (OSHA) of the Department of Labor or through individual Federal agencies that have the authority to regulate safety and health within their own jurisdictions. OSHA can impose standards and regulations on the workplace when scientifically valid research and empirical data indicate that conditions pose a significant risk of harm to workers. Interactions between biological rhythms and work schedules are examined through basic research on underlying biological mechanisms; applied research studying human responses to shift work in laboratory and field settings; statistical information on the occurrence of injuries, mishaps, deaths, and health problems in the workplace and the conditions under which they occur; and demographic information about populations working different schedules.

The effects of various work schedules on the health and safety of workers and the impact they could have on the public raise questions about possible Federal actions to regulate some work hours and schedules. These concerns are coupled, however, with questions regarding the extent of current knowledge about work schedules and their effects, namely:

- What types of schedules are being worked and by whom?
- What are the precise effects on the health, performance, and general well-being of workers who work nondaytime hours?
- What kinds of effects occur in what kinds of schedules?
- Who are the workers most likely to be affected?

What we envision as an internal clock is actually a group of neurons in the brain that control daily rhythms.

SOURCE: R.M. Coleman, *Awake at 3:00 a.m. by Choice or by Chance* (New York, NY: W.H. Freeman, 1986).

- What factors contribute to any observed effects and to what degree?
- What are the implications of these effects for worker safety and the safety of the public?
- What interventions can be taken to alleviate or lessen deleterious effects?
- Most important, is enough known at this time to recommend specific guidelines or regulations?

This report discusses current theories and ideas pertaining to these questions and describes the latest efforts to answer them.

CIRCADIAN RHYTHMS

Many biological activities rise and fall in rhythmic patterns in humans, other animals, plants, and even single-celled organisms. This ability to keep track of time, apparently a basic part of life, is under genetic control. Geneticists have identified specific genes in simple organisms that are responsible for rhythmic cycles, and physiologists have identified a certain part of the mammalian brain that controls rhythms in more advanced organisms. **Biological**

Box 1-B—Cycles That Last From Minutes to Days

Circadian rhythms are a basic and well-recognized feature of human physiology and behavior. However, biological rhythms that repeat more or less frequently than every 24 hours are also fundamental to the body's function. In general, ultradian rhythms (those with a length of less than 24 hours) and infradian rhythms (those with a length greater than 24 hours) do not coincide with conspicuous environmental cues, and how they are generated is not well understood.

Sleep cycles were one of the first ultradian rhythms characterized in humans. A complete cycle of dreaming and nondreaming takes place about every 90 minutes. This finding prompted researchers to hypothesize that cycles of enhanced arousal followed by diminished activity typify both waking and sleeping periods. This theory of a basic rest-activity cycle has led to many studies of ultradian cycles in alertness-sleepiness, hunger, heart function, sexual excitement, urine formation, and other functions.

Hormones are also released in ultradian cycles. Many are secreted in a more or less regular pattern every few hours. More frequent cycles of release, every few minutes, have also been documented. Although the mechanisms of hormone secretion have not been uncovered, patterned release has been shown to be extremely important for proper functioning. For example, experiments have shown that, when replacing a deficient hormone, pulses of the hormone, not a continuous supply, are required for effectiveness. Also, abnormalities in the production cycle of hormones have been correlated with altered function. Although these cycles do not appear to be tightly coordinated, it is clear that ultradian rhythms with a cycle of 90 minutes, as well as with cycles of a few minutes to several hours, are a basic component of many human functions. How they are generated is unknown.

The most prominent infradian rhythm in humans is the menstrual cycle. Through a series of complex interactions between the brain and reproductive organs, an egg is released by an ovary approximately every 28 days, and the reproductive organs are prepared for possible fertilization. During each cycle, hormones are secreted in varying amounts, and the reproductive tract and breast tissue are altered. Other systems, such as those involved in immune function, may also be affected.

Although the menstrual cycle has long been recognized, how it is generated and how it interacts with other factors have not been completely detailed. It is clearly affected by circadian rhythms. For example, a peak in the secretion of luteinizing hormone, which triggers ovulation, usually occurs in the early morning hours. Also, phase shifts, such as those produced by transmeridian flight, may interfere with the menstrual cycle. The menstrual cycle may also have therapeutic implications. A recent study of the timing of breast cancer surgery in relationship to the menstrual cycle has found fewer recurrences and longer survival in patients whose surgery occured near the middle of the menstrual cycle rather than during menstruation. That biological rhythms are often ignored is also indicated in this study: less than half of the records evaluated in the study recorded the time of the last menstrual period.

SOURCE: Office of Technology Assessment, 1991.

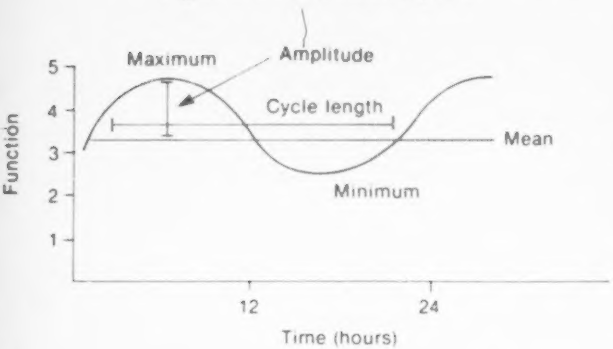
rhythms that repeat approximately every 24 hours are called circadian rhythms (box 1-B) (figure 1-1).

In humans, body temperature, the secretion of many hormones, the functioning of various organ systems (e.g., cardiovascular, pulmonary, renal) and the immune system, and sleep and wakefulness all exhibit circadian rhythms. In addition to these physiological activities, many psychological processes and mental functions that affect human performance exhibit circadian fluctuations. These include memory, reaction time, manual dexterity, and feelings of alertness. **The implications of human circadian rhythms for shift workers form the focus of this report** (figure 1-2).

When rhythms generated by the body are disrupted by changes in environmental cues, as they are in jet lag and in some work schedules, human function can be compromised until realignment is achieved. Patterns of sleep are disrupted, performance may be impaired, and a general feeling of malaise may prevail.

Circadian rhythms are generated by an internal clock, or pacemaker, that is located in a region of the brain called the suprachiasmatic nucleus. Circadian rhythms persist even in the absence of cues indicating the time or length of day, such as light and dark. In humans, as in most species, light-dark cycles are very powerful entraining, or synchronizing, agents, while sleep-wake schedules

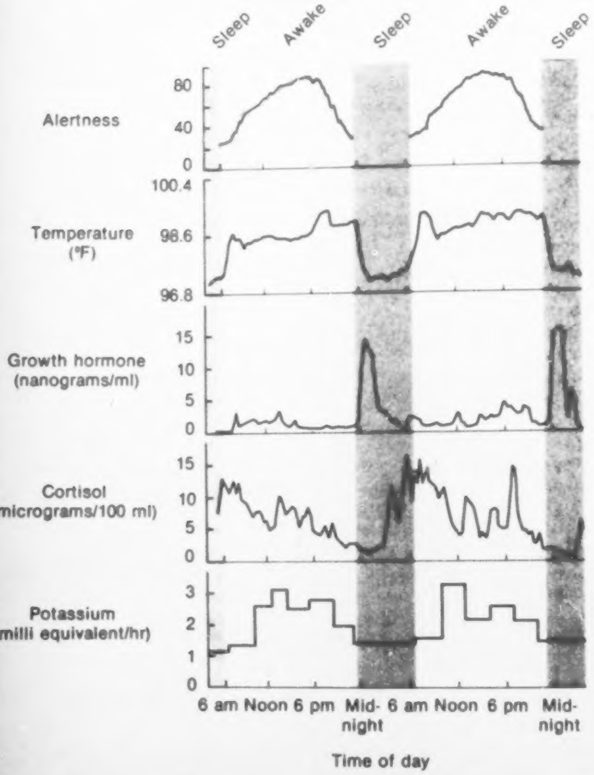
Figure 1-1—Circadian Rhythm



Circadian rhythms have a single cycle length of approximately 24 hours. The amplitude, a measure of the degree of variation within a cycle, is the difference between the maximum value and the mean.

SOURCE: Office of Technology Assessment, 1991.

Figure 1-2—Circadian Timing of Various Functions



The timing of some functions that cycle with a circadian rhythm.

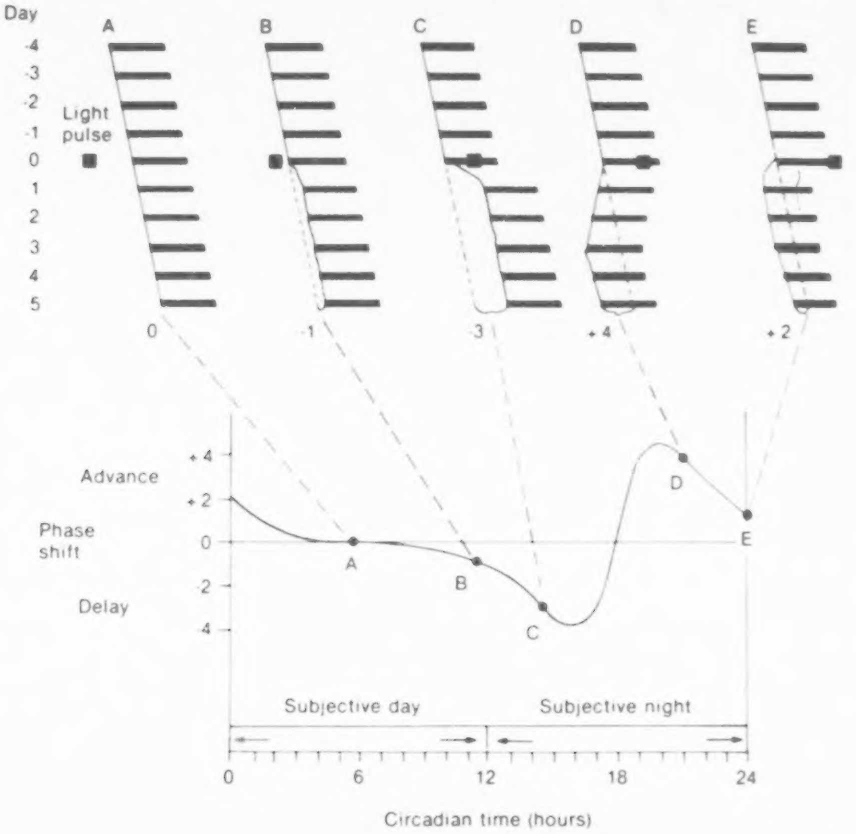
SOURCE: Adapted from R.M. Coleman, *Awake at 3:00 a.m. by Choice or by Chance* (New York, NY: W.H. Freeman, 1986).

and social cues may also synchronize human circadian rhythms. An entraining agent can reset, or phase shift, the internal clock; depending on when an organism is exposed to such an agent, circadian rhythms may be advanced, delayed, or not shifted at all (figure 1-3). When circadian rhythms are reset, the beginning and end of the cycle are shifted, but the length and progression of changes within it remain the same. The flexibility of a circadian rhythm in adjusting to different environmental cues will determine the degree to which the timing of the function controlled by that rhythm can be altered. In humans, this has direct implications for the ability of the body clock to readjust following changes in work schedules.

A standard schedule for most people is to awake in the morning and go to bed at night, some 15 to 17 hours later. The person who arises at 5 a.m. and the one who wakes 4 hours later both have 24-hour rhythms and spend the major part of their waking hours in the light and their sleeping hours in the dark, but they can have different phases. Some members of society have far different hours: a nurse or chemical worker who goes to work at midnight spends a major part of his or her waking hours in the dark and must sleep through daylight hours. In some situations, the work schedule changes in such a way that individuals will constantly be changing waking and sleeping times, and other functions that have a circadian rhythm will continually be readjusting to the new schedule.

While shift work may affect all circadian rhythms, its effect on performance rhythms and sleep-wake cycles are of particular concern. The timing of peaks in performance varies with the nature of the task, with peaks in many tasks (e.g., manual dexterity, simple recognition, reaction time) paralleling the peak in the circadian rhythm of body temperature. Also, sleep deprivation and sleepiness disrupt most types of performance. The timing and total amount of sleep are related to a person's environment and to other circadian rhythms, notably body temperature, with sleep occurring most readily when body temperature is low. When individuals are required to work at night, many types of performance can be affected, which can reflect both the effect of circadian rhythms and the lack of sleep. Thus, sleep deprivation, combined with the influence of the circadian pacemaker, can severely curtail performance at night.

Figure 1-3—Phase Response Curve



Experiments demonstrate that exposure to light at different points in a single circadian cycle variably shifts the internal pacemaker (A-E). The pulse of light given in mid-subjective day (A) has no effect, whereas the light pulses in late subjective day and early subjective night (B and C) delay circadian rhythms. Light pulses in late subjective night and early subjective day (D and E) advance circadian rhythms. In the lower panel, the direction and amount of phase shifts are plotted against the time of light pulses to obtain a phase response curve.

SOURCE: M.C. Moore-Ede, F.M. Sulzman, and C.A. Fuller, *The Clocks That Time Us* (Cambridge, MA: Harvard University Press, 1982).

Other factors also alter circadian rhythms. For example, many physiological and behavioral functions, notably sleep, are altered with advancing age in humans. As a result, adjustment to shift work schedules and transmeridian flight is more difficult among older people (age 45 and above) and a considerable proportion of older people complain of sleep problems. In addition, the timing of sleep is very susceptible to circadian disruption; it is now recognized that some types of insomnia most likely result from circadian rhythm abnormalities.

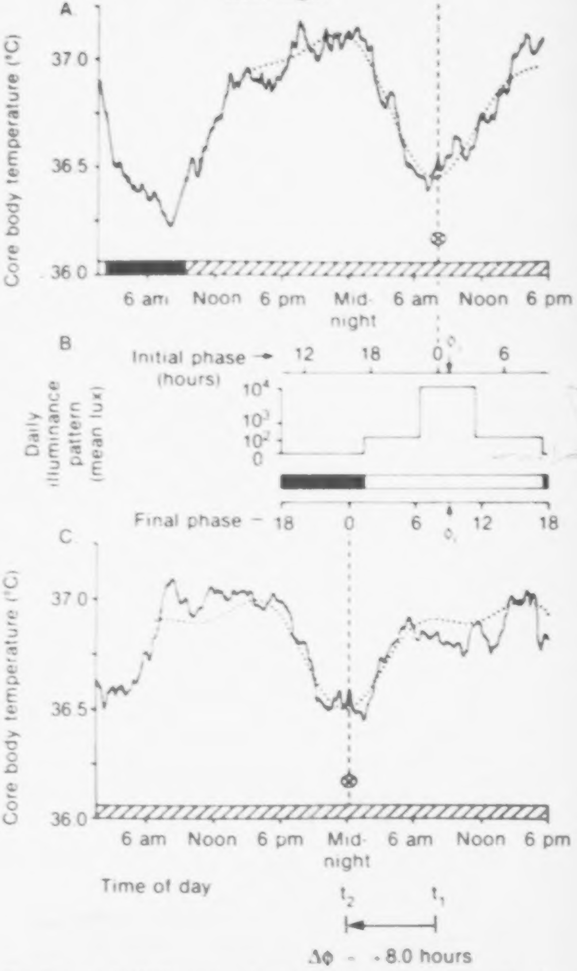
There is great interest in the role the circadian system may play in some mood disorders. It is hypothesized that circadian rhythms are advanced, delayed, or the amplitude dampened in seasonal affective disorder (SAD), a mood disorder characterized by recurring autumn or winter depression which is alleviated in the springtime; however, SAD has not been proven to be a circadian rhythm disorder. Also, it has been observed that people suffering from nonseasonal depression may exhibit altered circadian patterns in physiological functions and that their moods typically fluctuate daily, with improvement over the course of the day. These observations suggest a link between altered circadian rhythms and nonseasonal depression, although there is little direct evidence to support this hypothesis. Finally, some scientists are investigating the implications circadian rhythms have for the timing of surgery and the administration of drugs, in an effort to optimize their therapeutic effects.

Interest in manipulating the internal clock has grown with improved understanding of human circadian rhythms. Several agents show promise for manipulating circadian rhythms, and some are currently in use. Recent research indicates that light, especially bright light, is effective in shifting human circadian rhythms, although the mechanism is not well defined (figure 1-4). Researchers are investigating the capacity of melatonin, a hormone produced in the brain, to act as a circadian synchronizing agent in humans. Studies in animals suggest that administration of benzodiazepines, a class of hypnotic drug, affects the circadian system. It is not clear, however, whether the effect is due to direct action on the circadian clock or to the drug's ability to induce motor activity. Finally, there is some evidence that physical activity or arousal can synchronize the biological clock, but further experimentation is necessary to characterize this effect. The development or discovery of an agent that can manipulate the internal clock would be helpful in situations such as shift work, where a rapid realignment of the circadian system is desirable.

PREVALENCE AND USE OF SHIFT WORK

Shift work is required in any modern, industrially developed country, and it is indisputably part of work in the United States. Understanding shift work and its impact on productivity, health, safety, and quality of life depends on information about its prevalence and use. **The Office of Technology Assessment (OTA) finds that the Federal Government's collection of data pertaining to the prevalence and use of shift work has been inconsistent.** This has precluded any accurate, thorough measure of the scope and nature of shift work in this country.

Figure 1-4—Resetting the Human Pacemaker With Light

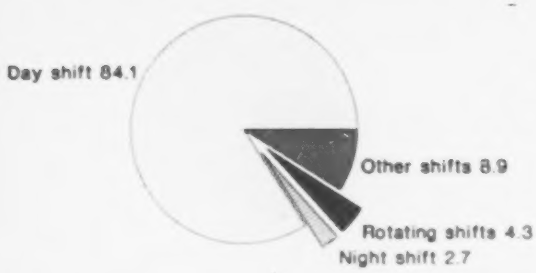


The first graph (A) illustrates the original circadian rhythm of body temperature. Following exposure to bright light, as illustrated in B, the rhythm of body temperature was significantly shifted (C).

SOURCE: C.A. Czeisler, R.E. Kronauer, J.S. Allan, et al., "Bright Light Induction of Strong (Type 0) Resetting of the Human Circadian Pacemaker," *Science* 244:1328-1332, 1989.

The most comprehensive data on the prevalence of shift work in the United States are based on the Current Population Survey (CPS), a household sample survey conducted monthly by the Bureau of the Census (in the U.S. Department of Commerce) for the Bureau of Labor Statistics (BLS) (in the U.S. Department of Labor). In this survey a set number of households are regularly asked a fixed list of employment questions. In May of each year between 1973 and 1980, a supplement was added to the CPS with questions on specific hours of employment, and in May 1980 data were collected for the first time on whether or not the principal job in the household was

Figure 1-5—Percentage of Shift Workers Among Full-Time Employees in the United States



SOURCE: E.F. Mellor, "Shift Work and Flexitime: How Prevalent Are They?" *Monthly Labor Review* 109: 14-21, 1986.

worked on a rotating shift. From 1980 through 1984, the CPS collected no information on work schedules. The next year, in May 1985, the supplement again included questions related to hours of work and work schedules. Since there have been no supplements since 1985 that include shift work questions, the 1985 data provide the most recent estimates available. These data indicate that **approximately one in five Americans—20 million people—is a shift worker.** Approximately 2.0 million individuals are night workers, and another 3.1 million people work rotating shifts, which may involve night work. The remaining individuals work other types of nonstandard work schedules, such as split shifts or evening hours. In 1991 another supplement was added to the CPS.

A more recent and comprehensive national source of data on shift work is the 1987-88 *National Survey of Families and Households*, conducted by the Center for Demography and Ecology at the University of Wisconsin. This survey asked the most detailed questions on work schedules of any national survey to date, including the hours work began and ended each day of the week and shift rotation. Although no analysis of the shift work data has been completed yet, preliminary results on prevalence are consistent with the May 1985 CPS findings.

Shift Work in Various Employment Sectors

Many occupations and industries use shift work; in fact, 15.9 percent of all full-time workers are engaged in shift work (figure 1-5). The factors that lead to shift work vary considerably from sector to sector.

Reasons for adopting shift work schedules include the following:

- an extended period of time required to complete a particular job or process;
- a constant need or extended demand for services;
- economic factors (e.g., expense of capital investment, concerns about competitiveness); and
- technological advances.

From 1979 to 1984, capital-intensive industries and continuous-process operations had as many as 50 percent of employees working evening or night shifts. In contrast, less than 3 percent of workers in labor-intensive industries are scheduled for an evening or night shift (table 1-1).

Shift work is also prevalent in transportation occupations and industries, including trucking, airlines, railroads, and shipping. Among those employed by public utilities and transportation industries, 20.6 percent are shift workers; 25.5 percent of full-time motor vehicle operators are shift workers, half of them on night or rotating shifts. While many transportation sectors are governed by hours of service regulations, those regulations do not preclude night work, shifts exceeding 8 hours in length, or erratic scheduling.

Round-the-clock operations are also demanded by various service industries, a significant and growing sector of the U.S. economy. More than 38 percent of persons employed full-time in service occupations are shift workers, compared to the average of 15.9 percent of all full-time employed persons. Some subgroups of the service sector exhibit an extremely high prevalence of shift work. For example, 60.8 percent of full-time protective service workers (e.g., police and firefighters) are employed during nonstandard hours. Among workers in other service industries, those employed in eating and drinking establishments (47.6 percent) and in entertainment and recreation (33.4 percent) are especially likely to be shift workers.

Technological advances—office automation and the increased importance of global communication and interaction—provided powerful incentives for [illegible] addition of a second and third shift. BLS reported [illegible] between 1978 and 1985 the number of clerical personnel working at night increased three times faster than the number of all other night workers.

Table 1-1—Shift Work in Various Employment Sectors

Occupation or industry	Total workers employed (thousands)	Standard work schedule (percent)	Shift work (percent)			
			Evening shift	Night shift	Rotating shift	Total
Occupation						
Managerial and professional specialty	18,944	91.4	2.0	1.2	2.7	8.6
Executive, administrative, and managerial	9,079	92.6	1.8	0.8	2.6	7.4
Professional specialty	9,866	90.3	2.3	1.5	2.8	9.7
Health-diagnosing occupations	212	77.6	1.7	—	13.6	22.4
Health assessment and treating occupations	1,257	68.7	8.3	8.3	12.1	31.3
Technical, sales, and administrative support	21,961	88.3	4.2	2.1	3.5	11.7
Technicians and related support	2,548	84.5	6.5	3.3	4.6	15.5
Health technologists and technicians	761	70.1	12.5	9.0	7.6	29.9
Sales occupations	6,730	82.8	4.1	2.2	6.9	17.2
Supervisors	1,957	84.0	2.8	2.1	7.4	16.0
Salesworkers, retail and personal services	2,400	72.3	8.3	3.6	11.5	27.7
Administrative support, including clerical	12,684	92.0	3.7	1.7	1.6	8.0
Computer equipment operators	673	81.2	11.0	2.7	4.1	18.8
Mail and message distributing	613	76.2	12.7	9.1	0.4	23.8
Service occupations	7,268	61.6	16.9	6.1	8.7	38.4
Private household	275	83.0	7.3	1.9	—	17.0
Protective service	1,286	39.2	19.8	7.2	23.8	60.8
Service, except private household and protective	5,707	65.6	16.7	6.1	5.7	34.4
Food service	2,194	56.9	21.2	5.3	8.2	43.1
Health service	1,076	63.9	14.8	10.3	6.8	36.1
Cleaning and building service	1,719	74.4	16.1	5.4	1.7	25.6
Personal service	718	73.9	7.5	3.7	6.2	26.1
Precision production, craft, and repair	10,477	87.0	6.3	2.2	3.7	13.0
Mechanics and repairers	3,582	87.3	6.0	2.3	3.6	12.7
Construction trades	3,282	94.1	3.4	1.0	1.2	5.9
Other precision production, craft, and repair	3,614	80.3	9.3	3.2	6.1	19.7
Operators, fabricators, and laborers	13,326	76.3	10.5	4.6	6.2	23.7
Machine operators, assemblers, and inspectors	6,748	76.3	13.2	3.7	6.2	23.7
Transportation and material-moving occupations	3,448	73.8	5.8	6.0	7.4	26.2
Motor vehicle operators	2,392	74.5	4.3	6.9	5.9	25.5
Handlers, equipment cleaners, helpers, and laborers	3,130	78.9	9.9	5.2	4.9	21.1
Farming, forestry, and fishing	1,418	89.9	1.5	1.4	0.7	10.1
Industry						
Private sector	60,127	83.5	6.6	2.9	4.4	16.5
Goods-producing industries	24,626	85.0	7.4	2.6	3.9	15.0
Agriculture	1,154	89.4	0.9	2.2	0.2	10.6
Mining	885	78.1	6.0	1.6	12.1	21.9
Construction	4,279	97.5	1.3	0.4	0.4	2.5
Manufacturing	18,309	82.1	9.3	3.2	4.5	17.9
Durable goods	11,277	84.0	10.0	2.5	2.8	16.0
Nondurable goods	7,033	79.1	8.2	4.4	7.2	20.9
Service-producing industries	35,501	82.4	6.1	3.0	4.8	17.6

Table 1-1—Shift Work in Various Employment Sectors—Continued

Occupation or industry	Total workers employed (thousands)	Standard work schedule (percent)	Shift work (percent)			
			Evening shift	Night shift	Rotating shift	Total
Transportation and public utilities	4,958	79.4	6.1	3.5	6.4	20.6
Wholesale trade	3,222	91.9	2.9	2.1	0.9	8.1
Retail trade	9,111	73.7	9.1	3.7	8.6	26.3
Eating and drinking places	2,242	52.4	21.0	5.3	12.5	47.6
Finance, insurance, and real estate	5,003	93.9	1.9	1.0	1.1	6.1
Services	13,207	82.9	6.4	3.3	3.9	17.1
Private household	345	80.8	7.3	1.5	0.7	19.2
Business and repair	3,242	87.4	5.8	2.4	3.1	12.6
Personal, except private household	1,379	74.0	10.1	3.8	6.6	26.0
Entertainment and recreation	529	66.6	13.8	2.2	7.3	33.4
Professional services	7,682	83.8	5.4	3.7	3.6	16.2
Hospitals	2,303	73.0	10.5	6.6	8.5	27.0
Public sector	13,268	87.2	4.6	2.0	3.7	12.8
Federal Government	2,901	86.2	6.1	3.4	2.8	13.8
State government	3,320	88.2	4.3	2.3	3.0	11.8
Local government	7,047	87.1	4.2	1.3	4.5	12.9

SOURCE: E.F. Mellor, "Shift Work and Flexitime: How Prevalent Are They?" *Monthly Labor Review* 109:14-21, 1986.

Night work among technical and professional office personnel has increased 36 percent during this time period.

Who Are Shift Workers?

A higher percentage of young men, single men, and black men are shift workers. Approximately 22.6 percent of black men employed full-time are shift workers, versus 17.3 percent of white men employed full-time. Among all men employed full-time, 27.4 percent of those between the ages of 16 and 19 do not work a regular daytime schedule, compared to 14.6 percent of men age 45 and older. Among all men employed full-time, 21.1 percent of single men and 16.5 percent of married men work nonstandard hours. **Although young, single, and black men are more likely to be shift workers, older, married, and white men, being the majority of full-time workers, form the majority of shift workers** (table 1-2).

Differences in shift work prevalence by sex depend on whether full-time or part-time work is considered. Considering only full-time wage and salary earners age 16 and over, the BLS reports that **17.8 percent of men and 13.0 percent of women are shift workers.** Men are more likely than women to be working night, miscellaneous, and rotating shifts, whereas women are more likely than men to work the evening shift. While men are more likely than women to be shift workers, shift work is highly prevalent among women in some employment sectors, particularly nursing and other health services.

One-fourth of all dual-earner couples without children and one-third of all dual-earner couples with children include at least one spouse who works a nonstandard shift. Moreover, shift work is especially high among married couples with young children. One study estimated that about 50 percent of all young couples with children under the age of 5 in the United States include at least one spouse who works nonstandard hours. Also, the prevalence of shift work is considerably higher among unmarried parents. **Both young dual-earner parents and unmarried employed mothers are especially likely to be working nonstandard hours.**

The reasons individuals work nonstandard hours vary and include both voluntary and involuntary factors. Voluntary reasons include better child-care arrangements, better pay, better arrangements for care of other family members, and more opportunity for education. Involuntary reasons include the inability to get any other job and the schedule being a requirement of the job. A survey by the BLS reported that **only 28 percent of persons working nonstandard hours did so voluntarily; 72 percent**

Table 1-2—Demographic Profile of Shift Workers

Characteristic	Total workers employed (thousands)	Standard work schedule (percent)	Shift work (percent)			
			Evening shift	Night shift	Rotating shift	Total
Age						
Men, 16 years and over	43,779	82.2	6.8	3.0	4.9	17.8
16 to 19	1,139	72.6	11.8	4.7	7.0	27.4
20 to 24	5,567	80.0	8.5	3.5	5.0	20.0
25 to 34	14,281	80.0	7.8	3.3	5.6	20.0
35 to 44	10,630	83.6	5.7	2.7	5.0	16.4
45 to 54	7,094	85.4	5.3	2.7	3.9	14.6
55 to 64	4,594	85.5	5.6	2.1	3.8	14.5
65 and over	474	85.4	2.8	2.5	4.0	14.6
Women, 16 years and over	29,616	87.0	5.5	2.3	3.3	13.0
16 to 19	777	71.1	12.8	4.0	9.4	28.9
20 to 24	4,346	84.0	6.7	2.0	5.1	16.0
25 to 34	9,510	87.5	5.3	2.2	3.3	12.5
35 to 44	7,080	88.9	4.8	2.3	2.2	11.1
45 to 54	4,753	88.4	4.6	2.2	2.8	11.6
55 to 64	2,838	87.3	5.3	2.6	3.2	12.7
65 and over	311	85.8	7.3	3.8	—	14.2
Total, 16 years and over	73,395	84.1	6.3	2.7	4.3	15.9
Race and Hispanic origin						
White	63,523	84.7	5.8	2.6	4.3	15.3
Men	38,588	82.7	6.3	2.9	5.0	17.3
Women	24,935	87.8	5.0	2.1	3.3	12.3
Black	7,847	80.1	9.8	3.5	4.3	19.9
Men	4,054	77.4	10.6	3.7	5.3	22.6
Women	3,793	83.0	8.9	3.2	3.2	17.0
Hispanic origin	4,911	84.6	7.1	2.5	3.3	15.4
Men	3,184	82.3	7.7	2.8	4.0	17.7
Women	1,727	88.8	5.8	1.9	2.0	11.2
Marital status						
Men						
Single, never married	9,703	78.9	9.3	3.6	5.0	21.1
Married, spouse present	29,666	83.5	5.7	2.7	5.1	16.5
Widowed, divorced, or separated	4,410	80.4	8.5	3.6	4.0	19.6
Women						
Single, never married	7,109	83.6	6.8	2.3	5.2	16.4
Married, spouse present	15,679	89.9	4.3	1.9	2.3	10.1
Widowed, divorced, or separated	6,828	83.7	7.0	3.3	3.6	16.3

SOURCE: E.F. Mellor, "Shift Work and Flexitime: How Prevalent Are They?" *Monthly Labor Review* 109:14-21, 1986.

did so involuntarily, and 9 out of 10 of the latter said the schedule was a requirement of the job.

Shift Work Schedules

Several hundred shift routines are in place in the United States, but data characterizing specific shift work schedules in various occupations and industries in the United States have not been collected by the Federal Government, labor representatives, or industry. The absence of these data, coupled with sparse demographic information about the populations of workers involved, severely handicaps the study of the health, performance, and social effects of shift work, as well as changes in trends concerning the use of shift work.

The most common work schedule in the United States, especially in the manufacturing sector, is 8 hours a day, 5 days a week on a single shift, followed by 2 days off. Shift work schedules can be used to cover 7 days a week of continuous operation, with shift lengths ranging from 8 to 12 hours. Shifts may be fixed, partially fixed, or rotating. Shift rotation—that is, the time a worker spends on one shift before moving to another—may be rapid (3 days) or gradual (4 weeks), and it may move forward

Box 1-C—The Compressed Workweek

The compressed workweek (CWW) refers to a schedule in which employees work approximately 40 hours in fewer than 5 days. A variety of schedules, with a variety of rationales, can be said to constitute a CWW. Typically, work is performed 10 or 12 hours per day, 3 or 4 days per week, and 3 or 4 days per week are free. Other possibilities include a long break schedule; for example a schedule of 12-hour shifts may employ a sequence of 4 days on duty, 7 days off duty, 4 days on, 3 days off, 3 days on, 1 day off, 3 days on, and 3 days off. As with all types of shift work, national data on the prevalence of specific CWW schedules are not available.

The CWW with 12-hour shifts appears to be common in the chemical industry (including petrochemical), the petroleum industry, offshore oil rigs, and ministeel industries. Other types of employment that could adopt the CWW include the paper industry, other manufacturing processes, utility industries (including nuclear powerplants), nursing and other health fields, clerical work, administrative work, technical maintenance, and computer operations.

Information derived from management and employee comments, limited psychological testing, and performance and safety records has highlighted some of the advantages and disadvantages of the CWW. In general, the CWW appears to increase worker satisfaction because it allows more days and weekends off. For example, in one plant, conversion to a CWW schedule with 12-hour shifts reduced the number of days on the job each year from 273 to 182. Also, when the CWW has 12-hour rotating shifts, fewer consecutive days are spent on the night shift and there is more time to recuperate than with 8-hour shifts 5 days a week. This may lessen the fatigue associated with rotating shifts and night work. While more days off may improve employee satisfaction, concerns about increased moonlighting have been voiced and have been documented in one case. In general, however, studies have failed to document an increase in moonlighting.

Data have suggested that not all employees endorse the CWW. Family responsibilities and previous work experience appear to influence preference for the CWW. One study estimated that 28 percent of work sites adopting a CWW will revert to the standard 8-hour day, 5-day week schedule. A few studies have indicated that women, especially those with young children, and older employees may be less satisfied with a CWW.

The use of the CWW, especially with two 12-hour shifts replacing three 8-hour shifts, may be more cost-effective for employers, since the number of shift changes is decreased (shift changes are the least productive time in an operation). Absenteeism also appears to be diminished when the CWW is adopted. Replacement of absent employees, however, may be more difficult with this schedule, since one common way of replacing an absent employee is holding over another from a previous shift, which is ill-advised for shifts of 12 hours.

Concerns over performance and safety have been voiced in relation to the CWW, although few studies have analyzed this issue. It has been suggested that fewer errors and accidents occur and productivity improves on CWW schedules. Other studies suggest that a 12-hour day, 4-day week produces more fatigue and poorer sleep and psychomotor performance than an 8-hour day, 5-day week.

Administrative problems may arise from the use of the 12-hour shift and the CWW. Since laws and regulations regarding hours of work are generally based on the 8-hour day and 40-hour workweek, computation of hourly wage and vacation time must be adjusted. Similarly, since exposure limits to noise, chemicals, and heat are generally based on the 8-hour day, they may need to be recalculated.

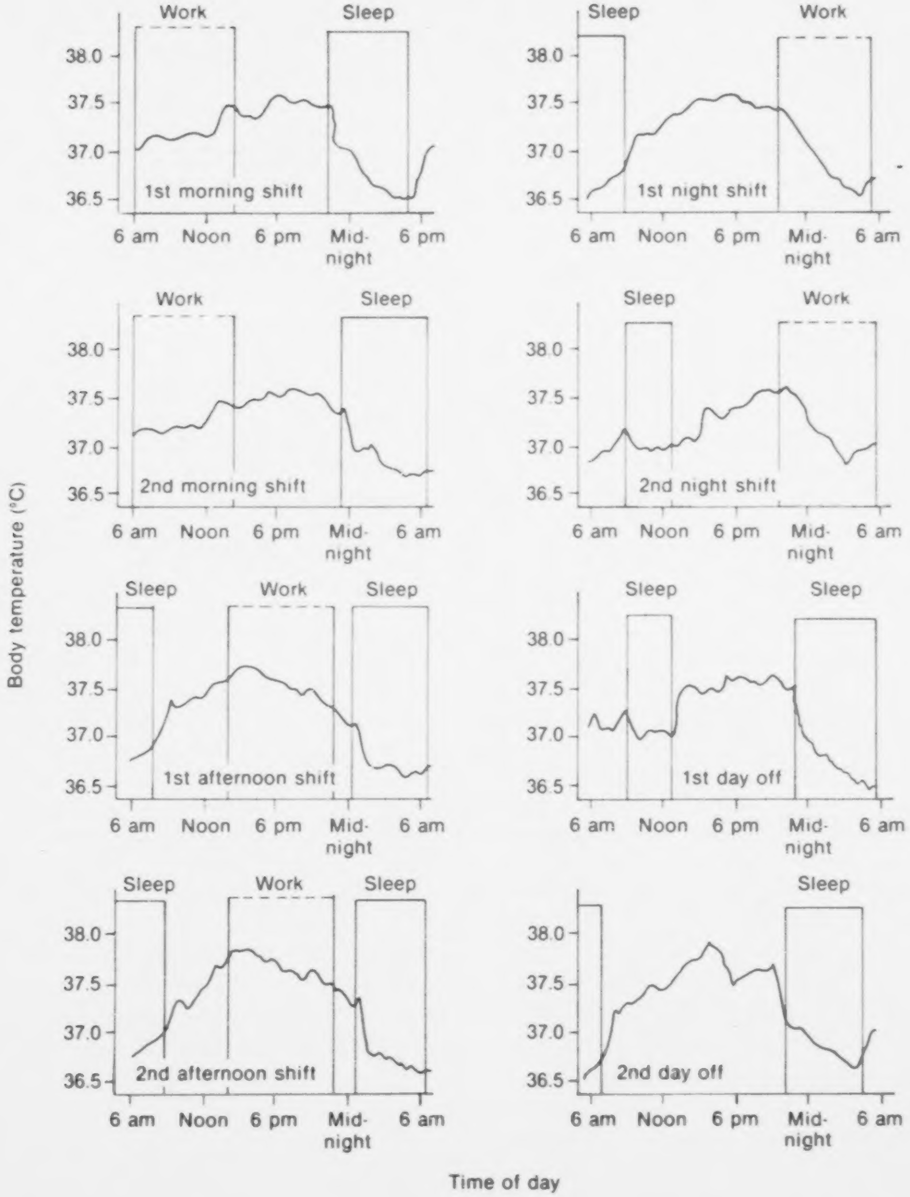
SOURCE: Office of Technology Assessment, 1991.

(day, evening, night) or backward (day, night, evening). Other types of scheduling, such as the compressed workweek (in which employees work approximately 40 hours in fewer than 5 days) and irregular scheduling (in which scheduled work shifts are variable and erratic), also exist. Compressed workweeks are used in the chemical and petroleum industries and are becoming more common in other employment sectors (box 1-C); irregular schedules are used in some employment sectors, including the transportation and manufacturing industries.

BIOLOGICAL RHYTHMS AND WORK SCHEDULES

Any work schedule that requires people to work when they would normally be sleeping (and sleeping when they would normally be awake) will conflict with the workers' circadian cycles and can cause disruption in circadian rhythms. These include irregular or rotating shift schedules, which cause workers to change constantly the hours that they work, or extended duty hours, which require them to

Figure 1-6—Relationship of Body Temperature, Work, and Sleep in a Rapidly Rotating Schedule



Graphs showing average body temperature of four workers on a 2-2-2 rotating shift system. On the night shift, the low point of body temperature coincides with the work period.

SOURCE: S. Folkard, D.S. Minors, and J.M. Waterhouse, "Chronobiology and Shift Work: Current Issues and Trends," *Chronobiologia* 12:31-54, 1985.

work for extended periods of time. In these situations, the physiological changes caused by circadian rhythm disruption often interact with other stressors associated with work schedules (i.e., fatigue, sleep deprivation, and social or domestic stress) to compound the effects on the health, performance, and safety of the worker.

Effects of Work Schedules

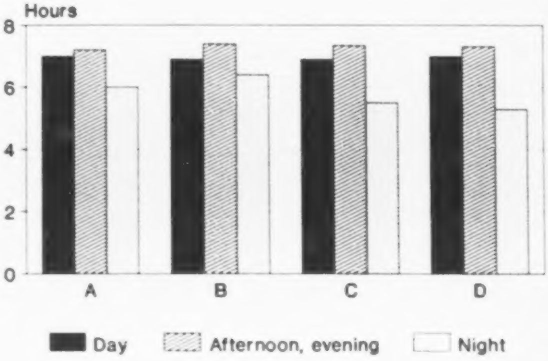
Human beings are naturally diurnal creatures, whose internal clocks are geared toward active wakefulness during the day and sleep at night. Most of society reflects this pattern. Normal work hours end in the late afternoon, and social activities, as well as the evening meal, usually a time for family conversation, follow. The shift worker, who goes to work or tries to sleep at that time, misses these activities. Shift workers end up fighting the diurnal trends and social attitudes that surround them. This creates three sources of stress:

- disruption of circadian rhythms;
- sleep disruption and fatigue; and
- social and domestic disturbances.

How much stress is placed on the worker by each of these sources varies, depending on the nature of the work situation and the schedule employed. The impact of these stressors and their resultant consequences may, in some individuals and some situations, lead to difficulties in coping with a work schedule. Indeed, some experts assert that shift workers never adjust to the stress associated with this work. However, there is great variability among people in their ability to adjust to shift work, with some individuals suffering few, if any, problems, and others finding certain work schedules intolerable. As a result, for some people shift work is an inconvenience, while for others it can have major adverse consequences. It should be borne in mind, however, that even those individuals who appear to adjust well to shift work may experience negative effects on factors such as performance or safety.

Work schedules can require an individual to be awake and active at an inappropriate time during the circadian cycle and can result in a state in which an individual's circadian rhythms are out of synchrony (figure 1-6). An inappropriately phased circadian system is in a state of disharmony akin to that of a symphony orchestra without a conductor. That disharmony can result in feelings of malaise and fatigue, disrupted sleep, and attempts to perform certain tasks at a less than optimal time in the circadian cycle. The degree to which individuals are affected by circadian disruption varies, with some people being better able to tolerate circadian desynchronization than others.

Figure 1-7—Length of Sleep of Permanent and Rotating Shift Workers



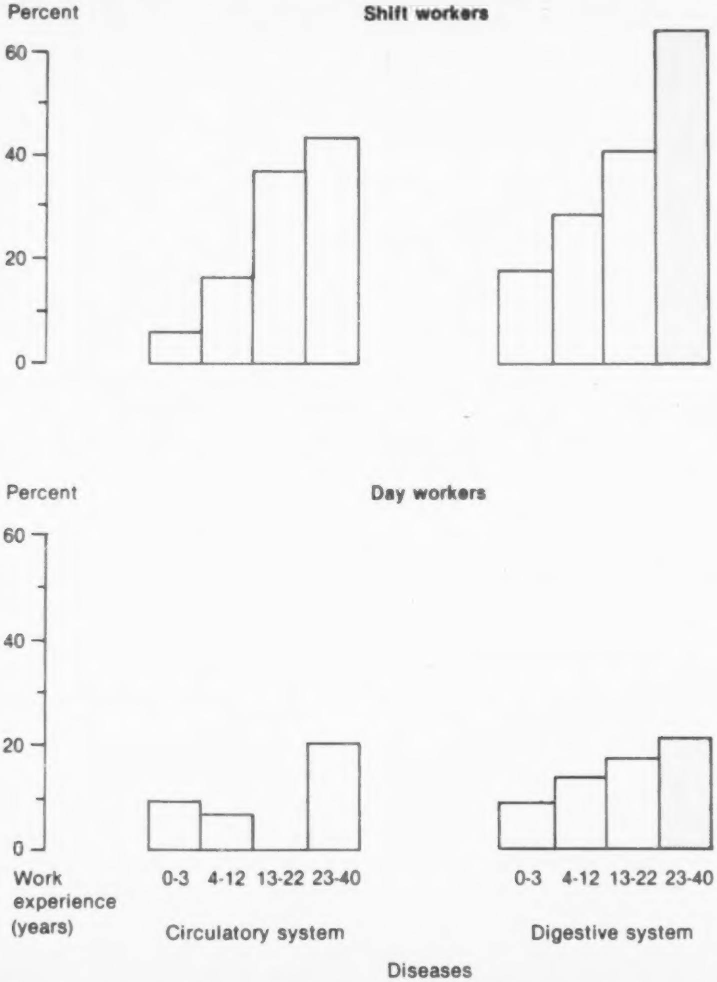
Average sleep lengths on different shifts for two samples of permanent (A,B) and rotating (C,D) shift workers. Rotating shift workers on the night shift had the shortest average sleep lengths.

SOURCE: M. Colligan and D. Tepas, "The Stress of Hours of Work," *American Industrial Hygiene Association Journal* 47:686-695, 1986.

Another prominent effect of work schedules, especially those that require night work, is sleepiness and fatigue (figure 1-7). One of the most common complaints among shift workers is the inability to sleep as long as necessary during the day, because of both internal factors, such as a desynchronized circadian system, and external factors, such as daylight, a noisy environment, and family and social demands. The net effect of these disruptions of sleep is often a state of chronic fatigue and sleepiness referred to as sleep debt. There is some variability among individuals in their ability to sleep, and persons who find it easier to sleep at odd times may adjust more readily to sleep disruptions caused by work schedules.

Finally, work schedules may induce stress by preventing workers from fulfilling family responsibilities and putting them out of synchrony with the rest of society. Social companionship, parenting, and sexual partner roles can all be compromised by work schedules, and carrying their domestic work-

Figure 1-8—Prevalence of Disease in Shift Workers and Day Workers



Percent of shift workers and day workers at an oil refinery, subdivided into groups according to work experience, suffering from circulatory and digestive diseases. Shaded bar indicates that there was a statistically significant difference between the shift workers and day workers.

SOURCE: Adapted from M. Koller, "Health Risks Related to Shift Work: An Example of Time Contingent Effects of Long-Term Stress," *International Archives of Occupational and Environmental Health* 53:59-75, 1983.

load is a major source of difficulty for women workers. Shift workers commonly feel alienated from the community because they are unable to attend evening or weekend educational, sports, religious, or recreational events and are unable to take advantage of community benefits.

These stressors can have a variety of consequences, including decreased well-being, chronic malaise, and poor sleep; increased gastrointestinal distress; and, perhaps, increased risk of cardiovascular disease and negative reproductive outcomes such as babies with low birth weight and preterm births (figure 1-8). While there has not been extensive research in the area, there is some evidence that decrements in performance occur as a result of nonstandard hours and that a number of factors besides circadian desynchronization contribute to them, notably sleep deprivation and fatigue. Information about how shift-work-induced performance decrements could affect productivity has not been collected.

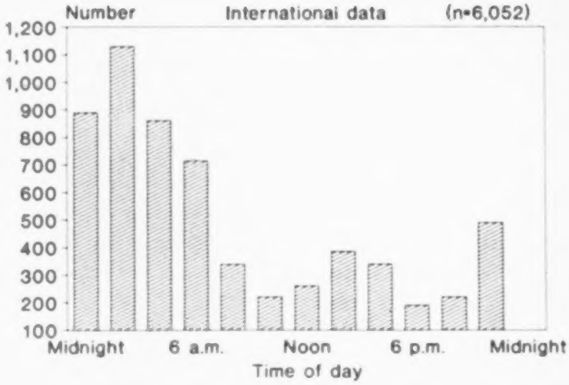
The implications of shift work for safety have not been examined thoroughly. Work schedules may affect not only the worker's safety, but the public's safety as well. Existing studies show that time-of-day effects and sleep loss and fatigue can contribute to transportation mishaps (figure 1-9), but the amount of information regarding their effects on rates of injury and mishap in other work settings is too sparse for any conclusions to be drawn. Additional data on the frequency, nature, and magnitude of such incidents are needed before measures to prevent them can be designed.

Interventions

A number of interventions to counteract the circadian desynchronization, sleep disturbances, and social disruption associated with shift work are being examined, but additional research is needed to understand the mechanisms at work in specific situations and to determine the effectiveness of these interventions.

While the most direct intervention is to devise less disruptive schedules, determining what is the best schedule is difficult. For example, the least disruptive schedule from a circadian perspective may not be optimal in terms of sleep and fatigue, or a schedule that tries to avoid sleep loss effects may create hardships for the worker in the social and domestic arenas. The "best" schedule varies from setting to setting, and the nature of a given job may dictate what is optimal. From a strictly circadian perspective, fixed shifts and shifts that rotate in a clockwise direction (mornings, evenings, nights) are probably the least disruptive; however, permanent night workers often suffer from chronic sleep disturbances, and the placement of shifts in a clockwise rotating schedule may provide less opportunity to prepare for and recover from the night shift. Expert opinion is divided as to whether a fast (1 to 3 days) or slow rotation (2 weeks or longer) is best, and it may be that consideration of the type of task to be performed (e.g., a simple repetitive task vs. one requiring memory) would be helpful to determine speed of rotation. One of the most popular rotation frequencies is 1 week. It is also one of the most problematic. One week is long enough to incur sleep deprivation but not long enough to allow for complete circadian readjustment, so the avoidance of weekly rotating schedules may be preferable from a circadian perspective. Furthermore, extended duty schedules that result in sleep loss and fatigue should be avoided.

Figure 1-9—Fatigue-Related Vehicular Accidents



The distribution, by time of day, of 6,052 vehicular accidents that were judged by investigators to be fatigue-related.

SOURCE: M.M. Mittler, M.A. Carskadon, C.A. Czeisler, et al., "Catastrophes, Sleep, and Public Policy: Consensus Report," *Sleep* 11:100-109, 1988.

Some interventions are designed to facilitate the process of adjustment to shift work. There is some evidence that bright light can help the circadian system adjust to work schedules, and medications that directly affect the circadian system or counteract the effects of fatigue and sleep problems are also being investigated. No drugs have yet been conclusively shown to have a direct effect on circadian rhythms. While certain compounds are helpful in inducing sleep (i.e., short-acting hypnotics, tryptophan, antihistamines) or maintaining alertness (i.e., amphetamines, caffeine), all have characteristics that prohibit regular use. The use of sleep and napping strategies to optimize a worker's ability to obtain adequate sleep is another area of investigation. Napping before a period of extended work is helpful in improving performance during the work period and can help workers on rotating shifts to supplement their sleep periods.

Other possible interventions include monitoring systems to detect when individuals may pose a risk to themselves or others because their performance is impaired. These can take the form of specific tests administered to workers on the job to determine if their performance on a task is suboptimal and systems that provide real-time, on-the-job feedback to the worker. Finally, educational programs that provide workers with information and strategies to deal with the problems they may face and ease some of the consequences of shift work are an important area of intervention research.

Research Needs

All conclusions and inferences about the effects of shift work are based on limited data. In the first place, the effects of work schedules are complex and often difficult to study. In the second place, OTA **finds that studies of shift work have received little support in this country.** Three basic types of studies have been used to examine the effects of shift work: field studies, in which subjects are studied in their actual work environment; survey studies, in which workers answer interview questions; and laboratory studies, in which the work situation is simulated in a controlled setting. There is a pressing need for research into how to apply basic knowledge about circadian rhythms and other factors in shift work to studies of the workplace. Research is needed to explain the various effects of work schedules, the variables that contribute to difficulties in adjusting to shift work, and interventions that could be used to counteract them. In addition, there is a compelling need for more studies of the interaction between work schedules and safety in the workplace. Crucial to this endeavor is more thorough collection of workplace data regarding hours of work and the occurrence of on-the-job accidents. The major mechanism for collection of data related to workplace injuries and mishaps in the United States is the BLS. **Currently, the data being gathered by the BLS provide no information that could help in assessing the impact of shift work on employee safety and health.**

LEGAL AND REGULATORY ISSUES

Current Regulation

Some Federal regulations on work hours are included in statutes and can be modified only by legislative action. In other instances, legislation delegates regulatory responsibility to an administrative agency which then promulgates requirements. Many existing regulations came about as a result of concern for public safety, notably within the transportation industry. In every case, existing regulations are concerned with total work hours in a fixed period of time, without specifically addressing shift changes or regulation of proportion of day and night work. There is also a substantial body of State regulation in the area of employee hours and conditions of work, some of which relates directly or indirectly to work scheduling.

The Hours of Service Act, which regulates work hours within the railroad industry, is an example of a statute that imposed specific requirements. First enacted in 1907, and enforced by the Federal Railroad Administration, it limits work hours for railroad employees and provides for penalties for violators. The Fair Labor Standards Act of 1938, which mandates a minimum wage for employees and requires that employers pay an overtime premium for time worked in excess of 40 hours a week, may influence work schedules indirectly. It also limits the hours that may be worked by children under 16.

The remainder of the current Federal regulation of work hours takes the form of requirements imposed by individual agencies, mostly within the Department of Transportation. Hours of service regulations are imposed by the Federal Highway Administration on truck and bus drivers, by the Federal Aviation Administration on airline crews and dispatchers, and by the Coast Guard on maritime crews. All of these regulations specify maximum permissible hours of service, and each contains details related to such issues as minimum rest periods, methods for recording hours of service, and penalties for violations. The Nuclear Regulatory Commission (NRC) has issued a policy statement concerning maximum work hours for licensed nuclear powerplant personnel. However, NRC policy statements are only enforceable if a plant voluntarily incorporates them into its technical specifications as part of the NRC licensing procedure.

Areas of Potential Regulatory Action

Action related to work hours could take two forms: the enactment of new (or amended) legislation covering work schedules or the promulgation of new regulations under existing statutory authority. With respect to the enactment of new Federal legislation, there is no serious question regarding the power and authority of Congress to take legislative action to regulate work hours. State legislatures also have authority to regulate economic matters, within the boundaries of both Federal and State constitutional limits.

The most likely source of authority to regulate work schedules would be safety and health statutes. Some of these deal specifically with occupational safety and health, notably the Occupational Safety and Health Act, which is implemented by OSHA. With a few exceptions, the act covers all private employees, and employers are obligated to comply both with the occupational safety and health standards issued by OSHA and with the general duty clause of the act. The general duty clause requires that an employer provide employees with a workplace "free from recognized hazards likely to cause death or serious physical harm." If OSHA were to determine that certain hours of work pose a safety or health hazard to employees, it could issue a specific standard, in accordance with the statutory procedures, or regulate it under the general duty clause. Standards and the general duty clause are enforced through workplace inspections, citations, and penalties. However, standards define employer obligations, while under the general duty clause, the employer's obligation is established on a case-by-case basis. Thus, regulation under the general duty clause would likely lead to less effective compliance and would be more burdensome for the agency. The Federal Mine Safety Act of 1977 empowers the Mine Safety and Health Administration to issue "mandatory health and safety standards for the protection of life and the prevention of injury in coal and other mines." It could regulate hours of work in mines in a manner analogous to that of OSHA in other industries.

Department of Transportation agencies have the statutory authority to regulate work hours (existing hours of service regulations), as do some other Federal agencies. The Railroad Safety Act of 1970 is designed to protect railroad employees, passengers, and members of the public who may be affected by railroad operations. Under the Energy Reorganization and Development Act the NRC has authority to issue regulations governing nuclear materials in order to protect health or to minimize danger to life or property. This could provide sufficient authority for the agency to regulate work schedules of covered employees.

The Labor-Management Relations Act regulates hours of work indirectly, by giving employees the right to bargain collectively and to enter into collective bargaining agreements. Under the act, the employer and the union must bargain in good faith; failure to do so is an unfair labor practice. The parties are obligated to bargain only in certain areas, including hours of employment.

CONCLUSIONS

There have been significant advances in the description and understanding of biological rhythms during the last decade. Basic research has delineated many physiological and cognitive functions that fluctuate in cycles, with circadian rhythms being the most thoroughly characterized. Further research is needed, however, into the mechanisms controlling biological rhythms, the role they may play in conditions such as aging and mental disorders, the implications of biological rhythms for clinical pharmacology and medicine, and the testing of interventions to manipulate them.

There have not been equivalent advances in the application of biological rhythm research to the workplace. Available data indicate that the biological rhythm disruption associated with nonstandard work schedules can, in conjunction with other factors, adversely affect the health and safety of workers. But there are significant gaps in the base of knowledge related to the precise nature of the effects that occur, the factors that influence individuals' susceptibility to them, and the prevalence and magnitude of such effects. Additional research and collection of statistical data on the workplace are needed in these areas.

Shift work is necessary in a modern, technological society. **An understanding of its effects on workers is essential in designing work schedules with the least negative impact on the worker and society, in developing interventions to alleviate the problems workers encounter, and in directing the guidance and regulation of work hours and work schedules.**

CASE STUDIES

To highlight the variety of settings in which shift work can be found, OTA has selected three case studies for closer examination. Each represents an area of employment in which nonstandard work hours may affect the public welfare as well as the individual worker.

Nuclear Powerplant Control Room Operators

Control room operators continuously monitor all indicators in the control room of a nuclear utility and oversee the operations of all of its components. These monitoring tasks require low-level sustained vigilance, which could be degraded by the effects of nonstandard work hours. Typically, powerplant control room operators work either an 8- or 12-hour per day rotating shift schedule.

The NRC licenses all nuclear powerplants and has authority over them. It has issued policy statements providing guidance on total working hours and maximum consecutive hours of work for nuclear powerplant operators. Although NRC policy statements are not enforceable per se, if a plant chooses to incorporate them into its technical specifications or administrative procedures, it must then follow those policies. To date, 77 of the 111 nuclear powerplants licensed by the NRC have incorporated the policy statements regarding work hours into their technical specifications. The NRC provides no guidance or policy regarding the specific design of work schedules. A panel convened under contract to the NRC has made recommendations, but no action has been taken on them to date, and they remain under consideration by the NRC.

Although the primary responsibility for monitoring employees on the job rests with the management of the utility that operates the powerplant, the NRC maintains resident inspectors at all plants as a means of monitoring compliance with regulations. If an inspector observes that individuals are not performing their duties adequately, he or she notifies the appropriate supervisor. Beyond the supervision provided by the utility management and the observational oversight of the NRC resident inspectors, the NRC has set forth no specific guidelines or regulations for monitoring control room operators for performance deficiencies related to sleepiness, fatigue, or disrupted biological rhythms. The Commission has instituted regulations regarding fitness for duty which are intended to ensure that all operators and plant personnel are reliable, trustworthy, and not under the influence of any substance (legal or illegal), or mentally or physically impaired from any cause, that would affect their ability to safely and competently perform their duties. Currently, this program is designed only to detect individuals using legal or illegal substances. If deemed necessary or desirable, it could be modified to include monitoring for decrements in performance caused by sleepiness, fatigue, or circadian desynchronization.

Registered Nurses and Resident Physicians

Registered Nurses

Registered nursing, the largest health care profession, is a predominantly woman's profession. The preponderance of women in nursing makes it difficult to generalize from studies of shift work in industries that employ primarily men. Shift work is a common part of nurses' lives, but there are no national data about the prevalence of shift work in nursing; few studies of the short- or long-term consequences of shift work for nurses' family and social life, health, and work performance; and few studies of the impact of different shift schedules on the quality of patient care. The information that is available indicates that a sizable proportion of registered nurses work some nondaytime hours and that shift work and the perceived lack of control over scheduling are important factors in nurses' job dissatisfaction and job turnover. Nurses typically work five 8-hour shifts per week on either a fixed or rotating basis, although other schedules are sometimes used. Higher hourly wages for evening and night shifts are common.

A study of nurses found that rotating shift work was associated with more digestive problems, more tension and stress, higher rates of injury, and disruptions in family and social life. As with shift workers in general, sleep disturbances are common among nurses working nondaytime hours. Some studies have found that nurses on rotating shifts take more sick days and rate themselves lower on job performance. Very little research has been conducted on the relationship between shift work and quality of patient care by nurses. What research has been conducted suggests two means by which shift patterns might affect quality of nursing care. First, patterns that are more compatible with circadian rhythms could result in less fatigue and increased alertness on the job. Second, shift work patterns that are more satisfying to nurses could result in greater nurse retention, unit cohesiveness, and continuity of care across shifts.

More research is needed on various shift work issues related to nursing, including the impact of changes in the health care system on workload, shift work, job stress, and related issues. Hospital nurses today must cope with decreased length of patient stay and increased severity of disease as a result of prospective reimbursement of hospitals. These factors may exacerbate work stress and health problems in general, independent of shift work, or they may interact with shift work to produce extremely high stress levels among those nurses working undesirable shifts and confronting patients who require more intensive nursing care.

Resident Physicians

Medical resident training has a long-standing tradition of extended duty hours, often including on-call periods of 24 hours or more. The major rationale for these schedules has been to provide continuity of care by observing and treating the patient over an extended period. Traditionally, the possible negative consequences of these schedules, such as fatigue and sleepiness, which could have a detrimental impact on resident performance and quality of life, have received minimal attention. Recently, however, consideration of these consequences has increased, partially as a result of an incident in 1984 in which a young woman died while being treated at a hospital in New York. An investigation found that of the five factors contributing to her death, one was that the resident who treated her had been on duty for an extended period of time (the other four were related to the level of supervision of the residents and other treatment-related issues). In response to this incident, the State of New York enacted regulations that limit the hours of work of hospital house staff. Implementation of these regulations has had a high financial cost, increasing New York State's health department budget by 3 percent.

Length of resident hours has traditionally been the concern of the Accreditation Council for Graduate Medical Education (ACGME). Within the past few years, ACGME has moved to revise its requirements for working hours and supervision of residents by having its Residency Review Committees (RRCs), which oversee the various medical-surgical specialties, introduce new standards. The responses of the RRCs ranged from specific (emergency medicine: no more than 60 hours per week with 12-hour shifts), to general (thoracic surgery: responsibility of program director to ensure reasonable in-house duty hours), to no response (general surgery and psychiatry). These revisions were made during 1988-89 and took effect in the summer of 1989.

Information regarding the effects of extended duty hours on residents and their patients is meager. While anecdotal evidence supports the idea that sleep deprivation associated with resident on-call schedules can affect patient care, the studies that have been conducted are equivocal. It is reported that extended duty hours prolong the time it takes to perform tasks but have no effect on the quality of performance. There is even less information available on the contribution long hours can make to health and family interactions.

The debate over the necessity for extended duty hours for medical residents remains unresolved. Until more information is gathered, a determination of what will best serve the needs of the doctors and the patients they care for cannot be made.

The Military

Many military situations demand that personnel engage in duty schedules that can lead to circadian rhythm disruption, sleep loss, and other stressors. The operational situation surrounding an activity determines the tempo at which tasks are to be performed and the nature of the stressors associated with job performance. A task performed during routine operations or in training, for example, is very different when performed under actual or simulated combat conditions. Usually, activities that occur in conjunction with combat or training for combat are marked by an increased tempo and sustained hours of duty. Since sustained operations requiring prolonged performance are integral to modern military operations, some of the most salient problems encountered are sleepiness and fatigue. Military tasks that could be affected include vigilance tasks, which require concentrated attention and alertness (e.g., electronic tracking and surveillance, sentries); operation and control of vehicles (e.g., aircraft, mobile weapons systems, boats); maintenance, preparation, and operation of equipment (e.g., weapons systems, communication systems); and command and control activities.

Few specific military regulations or guidelines relate to hours of service and scheduling, although all services do regulate flight operations. These regulations specify maximum allowable hours of flight duty and may include stipulations regarding transmeridian flight, minimum necessary rest periods, and the scheduling of flight operations. The Navy has specific guidelines, which have been used for centuries, for the scheduling of watches on board ships. They require that personnel standing watch constantly vary their hours of activity and sleep, which results in a constant state of circadian desynchronization. Beyond these regulations and guidelines, decisions regarding hours of duty and work schedules for military personnel are generally left up to commanding officers, who base their decisions on their knowledge of mission requirements and on the condition and limitations of their personnel.

POLICY ISSUES AND OPTIONS FOR CONGRESSIONAL ACTION

OTA has found that the significant progress made in recent years in the understanding of biological rhythms has not been matched by comparable advances in the understanding of biological rhythm disruption and its interaction with other factors in shift work. The limited information from research aimed at applying basic information about biological rhythms to work settings indicates that problems can arise as a result of nonstandard work schedules and that these problems affect the health, well-being, and safety of workers, and in some instances the public's safety. However, further clarification and definition are needed to determine the precise nature, prevalence, and magnitude of such problems. It is clear that for some workers nonstandard work hours impose a hardship that needs to be recognized and addressed. Three policy issues related to biological rhythms and work schedules were identified in the course of this assessment:

- the level of the Federal research effort in this area;
- the adequacy of Federal mechanisms for collecting workplace safety data related to hours of work; and
- the role of Congress in ensuring the well-being of men and women who work nonstandard hours.

Associated with each policy issue are several options for congressional action. Some of the options involve direct action. Others involve congressional oversight or direction of the executive branch. The order in which the options are presented does not imply any priority. Moreover, the options are not, for the most part, mutually exclusive; adopting one does not necessarily disqualify others within the same category or in any other category. Implementation of a combination of options might produce the most desirable effects. It is also important to keep in mind that changes in one area may have repercussions in other areas.

Issue 1: Is the current Federal research effort on the effects of work schedules and the mechanisms for collecting information on work schedules adequate?

Various Federal departments and agencies direct and fund intramural and extramural research programs about biological rhythms and the effects of work hours. Some programs are dedicated to basic research related to biological rhythms, while others are concerned with workplace issues. Many, especially those devoted to applied research in the workplace, are limited in scope and are minimally funded. Often, these programs focus on settings directly related to the funding agency (e.g., the Federal Railroad Administration conducts research on railroad operations, the Department of Defense studies military operations, etc.). Although the information derived from such studies may be applicable to other situations, few programs are devoted to studying general issues related to work schedules. The National Institute of Occupational Safety and Health (NIOSH) in the Department of Health and Human Services is an appropriate agency to fund and conduct such research, but only a small component of its research effort is devoted to this area. Moreover, NIOSH itself is a relatively small agency, and it may be unable to expand research in any area without an overall increase in size.

The Bureau of Labor Statistics (BLS) is responsible for the collection of workplace data. Its collection of data on the demographics, prevalence, and use of shift work is sporadic and inconsistent. The last collection of any such data was in 1985, with another scheduled for 1991.

Option 1: Take no action.

If Congress takes no action, the Federal research effort on the effects of work hours will continue at its current pace and extent. Information from basic research on biological rhythms and other pertinent factors will continue to be gathered, while research applying that knowledge to studies in the workplace will remain limited. Statistical data that would facilitate and augment this research will continue to be gathered in a nonsystematic fashion. Taking no action will forestall the gathering of information about the precise effects of various work schedules on workers—information that is needed to better understand what effects occur, to develop interventions that will help workers cope with these schedules and to steer guidance and regulation related to the design of work schedules.

Option 2: Create a Federal interagency task force to guide research efforts.

Congress could direct the establishment of an interagency coordinating group to ensure maximum use of U.S. research resources. Given the cross-agency nature of issues related to hours of work, the Committee for Health and Life Sciences of the Federal Coordinating Council for Science, Engineering, and Technology under the auspices of the Office of Science and Technology Policy is an appropriate body to assume this role. The Committee could coordinate research efforts across Federal agencies and set priorities for research. This would expedite the transfer of information from basic research to applied settings. The Committee could also set priorities for the collection of statistical data on the workplace by pertinent Federal agencies, which would facilitate research.

Option 3: Convene a national commission of nongovernmental experts on biological rhythms, work schedules, and their effects.

Congress could direct that a national commission of nongovernmental experts be established to provide guidelines for research priorities and directions. Since the guidance provided by such a commission would affect several Federal agencies and departments, the commission could be directed to submit its findings to the Federal Coordinating Council for Science, Engineering, and Technology within the Office of Science and Technology Policy to ensure the widest possible dissemination of its recommendations. The findings and recommendations of this commission could be used to coordinate and direct research efforts in this area.

Option 4: Direct the Bureau of Labor Statistics to expand the scope of its collection of data related to work schedules and hours worked.

Congress could direct the BLS to increase the consistency and scope of its collection of data related to hours of work. This could include information regarding the types of schedules being used in various industries and occupations and the demographics of the populations involved. Such data could be collected at regular intervals to ensure an up-to-date database. Before initiating this effort, representatives from the BLS could meet with representatives from the Occupational Safety and Health Administration (OSHA) (in the Department of Labor), NIOSH, and other pertinent agencies to determine what information is needed and the best format for its collection. These data would provide a clearer picture of the nature and extent of work schedules being used in the United States and the people who work them. If Congress takes this action, it will ensure the availability of pertinent information regarding the use of work schedules.

Option 5: Expand intramural and extramural research programs at the appropriate agencies and departments.

Congress could increase Federal research on the impact of work schedules on workers. This could include directing the pertinent Federal agencies to expand existing research programs and to develop new programs, as well as increasing appropriations of funds to support these efforts. Programs examining general issues related to hours of work could be carried out by agencies within the Department of Health and Human Services, notably NIOSH, and the Department of Labor, while industry-specific studies could be conducted by appropriate agencies, such as the agencies of the Department of Transportation and the Department of Defense.

OTA concludes that available information fails to answer questions about possible impacts of shift work on health and safety and provides very little information about possible interventions to alleviate any effects. While those answers and that information can be obtained, to do so in a timely manner will require increases in research support.

Issue 2: Are current Federal mechanisms for the collection of workplace safety statistics adequate?

BLS is the collector of workplace data related to injuries and mishaps. Currently, BLS forms for reportable injuries and illnesses include no questions regarding time of day, hours of work, or work schedules associated with an incident. OSHA may record information on time of day and hours of work in its investigations of workplace fatalities and catastrophic incidents in which five or more people are injured or substantial damage to property occurs. The National Transportation Safety Board routinely collects information regarding the role that hours of work might play in mishaps. Other Federal agencies and departments may examine the role of work hours when investigating incidents that occur within their domains. This information is used to help determine the cause of an event and is available to investigators who want to examine possible contributing factors in various types of work-related incidents.

Option 1: Take no action.

Workplace safety statistics will continue to be collected in the current fashion if Congress chooses to take no action. The data currently being collected by the BLS provide no information that could facilitate the assessment of the impact of work hours on employee and public safety, and the data collected by other agencies may or may not do so. Lack of this information makes it difficult to determine the frequency and severity of effects various work schedules can have on employee—and public—safety in different settings and occupations.

Option 2: Direct that the Bureau of Labor Statistics increase its collection of workplace data.

Congress could direct the BLS to gather information on work schedules and hours of work in its collection of data related to occupational injuries and illnesses. Since including this information on the BLS log sheets would increase the amount and complexity of information an employer would have to provide following a workplace incident, the BLS could first assess the feasibility and best method of obtaining such data. This information could include the time of day an incident occurred, the schedule being worked by the individual involved, and how many hours the person had worked previously. The resulting database could be analyzed to clarify the relationship between hours of work and workplace accidents and illnesses. In addition, the BLS could conduct targeted studies through its work injury report activity to describe relationships between work schedules and injuries.

Option 3: Direct the Occupational Safety and Health Administration and other agencies that collect workplace safety information to record information on hours of work related to safety incidents.

Congress could direct Federal agencies and departments that are involved in investigating safety-related incidents to routinely collect information related to work schedules and hours of work. This action would guarantee the availability of information that would make it possible to assess the contribution of work hours to the occurrence of accidents in various work settings and occupations.

Issue 3: Should Congress take steps to ensure the well-being of workers engaged in nonstandard hours of work?

Shift workers are exposed to a variety of circumstances and conditions not associated with standard daytime schedules. While much information is still needed, it is clear that nonstandard work hours can have a variety of effects on some workers. Gastrointestinal complaints, difficulty sleeping, and disruptions in family and social life are common and may affect the performance, well-being, and safety of the worker—and, by extension, the public. While there are some actions that can be taken to assist workers in coping with some of these conditions and to lessen their impact, there is currently little awareness of them, either in government or in private institutions. While concerns raised by nonstandard hours of work do receive some Federal attention within specific domains, the extent of activity in this area is narrow and inconsistent.

Option 1: Take no action.

If no action is taken, the recognition and awareness by government and private institutions of the impact of nonstandard work schedules will remain at its current level. Most shift workers will have little, if any, information to help them adjust to their work schedules and few resources to assist them with problems they may encounter. Furthermore, employers may not be aware of interventions to reduce the impact of the problems posed by shift work. Recognition by Federal agencies of the effects nonstandard work hours can cause and the importance these agencies place on monitoring and responding to them will continue to be low.

Option 2: Encourage the development of educational programs and support services for workers.

Congress could direct the Public Health Service, in the Department of Health and Human Services, and other Federal agencies to develop programs to educate shift workers about the demands and stressors they may encounter as a result of their work schedules. Congress could also provide incentives to private industry to do likewise. These programs could tell workers and their families about actions, such as sleep and dietary strategies, they can take to lessen some of the negative effects that may occur. Congress could also encourage the development of support services in the workplace, such as counseling and guidance programs, that would be available for workers encountering difficulties associated with their work schedules.

Option 3: Direct the Occupational Safety and Health Administration to determine whether the issuing of standards related to hours of work and scheduling is warranted.

Under the Occupational Safety and Health Act, OSHA may issue standards related to safety or health risks that exist in the workplace. OSHA issues standards once it determines there is sufficient evidence that a hazard exists. Congress could direct OSHA to evaluate the latest research on work hours to determine if there is sufficient information regarding health and safety impacts to guide the development of standards related to shift work. Available information regarding the effects work schedules can have on the health and performance of workers, their prevalence, and how they impinge on safety would have to be considered. This evaluation could involve Federal, State, and industry officials, researchers, and representatives of labor organizations. In addition, Congress could direct OSHA to keep up-to-date on progress in this field and to take any action that might be warranted by new developments and findings.

Option 4: Direct Federal agencies with authority over health and safety to review current regulations and determine whether they adequately address concerns raised by nonstandard work hours.

A number of Federal agencies have the authority to regulate health and safety requirements within their jurisdiction. Many of these agencies currently have hours of service requirements regulating certain aspects of work schedules. Congress could direct these agencies to review their current regulations to ensure that they are consistent with, and incorporate the results of, the latest research on shift work and its effects on health and safety. This would also require pertinent agencies to increase their surveillance and collection of data regarding the impact of shift work on worker health and safety in their domains.

Option 5: Encourage labor and management to include provisions regarding the safety and needs of shift workers in collective bargaining agreements.

As part of the good-faith bargaining conducted under the Labor-Management Relations Act, agreements regarding scheduling and hours of work are often struck between labor and management. Congress could encourage labor and management representatives to include in their deliberations safety and health concerns that some work schedules raise and the special requirements and needs of workers exposed to nonstandard hours. While neither labor nor management is under any obligation to respond to congressional interests, taking this action would indicate Congress' concern about the matter.

Option 6: Direct that measures be taken to further ensure individual and public safety in settings where nonstandard work hours are in effect.

Nonstandard work hours are often associated with safety concerns. Congress could direct the Department of Labor and other agencies to increase efforts to ensure that threats to worker and public safety are being adequately addressed. This could include increased surveillance of compliance with existing regulations regarding hours of work and investigation into the development of devices and interventions that can lessen hazards.

Chapter 2

Introduction and Overview

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Chapter 2
Introduction and Overview

A factory whistle blows and the workers leave their stations, punch the clock, and file out into the morning light. The graveyard shift is over. In a scene that is repeated across the country every day, these workers head home to face their nighttime, a nighttime that is at odds with the rest of society and the worker's own internal clock. This is shift work, and whether it involves a factory worker, a waitress at an all-night diner, or an interstate truck driver, this kind of scheduling can produce deleterious effects on the worker and the public.

Shift work, including any permanent schedule of extended duty hours, is an example of how the body's internal clock can be upset by external factors. Another common example is jet lag, the malaise associated with travel across time zones. In the case of jet lag, the effect is short-lived and the body readjusts relatively quickly. In the workplace, however, disturbances of the body clock can continue unabated, and other factors, such as loss of sleep and social disruption, can rapidly come into play to compound the effects. For some workers, when this occurs the results can be deleterious consequences for their health and ability to perform their jobs, which in turn can have detrimental effects on their safety and that of society as a whole.

What we envision as an internal clock is actually a group of neurons in the brain that control daily rhythms.

SOURCE: R.M. Coleman, *Awake at 3:00 a.m. by Choice or by Chance* (New York, NY: W.H. Freeman, 1986).

This provokes several questions: What is the body's internal clock, what is its purpose, and how does it work? For individuals and society as a whole, how does shift work affect productivity, health, and safety? Depending on the answer to the last question, what should be done to lessen the detrimental effects of shift work?

THE BODY CLOCK

One of the most predictable features of life on Earth is exposure to the rhythmic environmental changes caused by the planet's movements. As described by one scientist, ". . . the rotation of the Earth on its polar axis gives rise to the dominant cycle of the day and night; the revolutions of the Earth around the Sun give rise to the unfailing procession of the seasons; and the more complicated movements of the Moon in relation to the Earth and the Sun give rise to the lunar month and to the tidal cycles" (7). Given the pervasiveness of these rhythms, it is not surprising to find that most organisms show alterations in their bodily processes and their behavior in response to them. These cycles are called biological rhythms, and the internal biological mechanisms that control them are the body clock (box 2-A).

Biological rhythms provide a temporal framework for an organism's behavioral and physiological functions (7). For example, many flowers open and close at certain times of day or night, and honeybees time their visits to plants to coincide with these cycles. This increases pollination for the plants and the collection of nectar for the bees. The activity of organisms that live along the shoreline is often in synchrony with the ebb and flow of the tide, ensuring that feeding occurs at the optimal time. Certain animals are active and search for food only at night (nocturnal), while some do so only during the day (diurnal). These are just a few examples of the diverse activities and functions guided by the body clock.

Box 2-A—Biorhythms Are Not Biological Rhythms

The scientific study of the biological rhythms of the body should not be confused with the theory of biorhythms. No evidence exists to support the concept of biorhythms; in fact, scientific data refute their existence. Based on a theory first proposed by the German scientist Wilhelm Fliess in 1897 and popularized in the 1970s, biorhythm theory postulates that three cycles act in a concerted fashion to guide activity: a 23-day cycle that influences physical strength, endurance, energy, and physical confidence; a 28-day cycle that influences feelings, love, cooperation, and irritability; and a 33-day intellectual cycle that influences learning, memory, and creativity. According to biorhythm theory, these three cycles are linked to an individual's birth date and fluctuate in a constant fashion throughout his or her life. Each cycle has a high and a low point. By mapping the high and low points of the respective cycles and how they coincide or diverge, the theory states, performance can be charted, and critical days when performance can be expected to be highest or lowest can be predicted.

Although a theory that provides a system for predicting human behavior and scheduling activities has appeal, none of the contentions of biorhythm theory can be supported. No biological process with such a relationship to the calendar date of birth has ever been identified, nor have any studies attempting to validate biorhythms been able to do so. Thus, for example, attempts to validate the hypotheses using retrospective airplane crash reports and athletic scores have consistently failed. While there clearly are human biological rhythms with cycles that can be measured in days (the menstrual cycle being an example), there is no evidence for the existence of any of the three biorhythms, let alone any predictive interaction. Given its nonfactual basis, biorhythm theory is relegated to the realm of other popular pastimes, such as numerology, that can serve as a source of entertainment but have no substantive or predictive value.

SOURCE: D.C. Holley, C.M. Winget, C.M. DeRoshia, et al., *Effects of Circadian Rhythm Phase Alteration on Physiological and Psychological Variables: Implications to Pilot Performance (Including a Partially Annotated Bibliography)*, NASA technical memorandum TM-81277 (Moffet Field, CA: National Aeronautics and Space Administration, March 1981).

While biological rhythms are driven by an internal clock, external factors usually entrain, or synchronize, those rhythms with the physical environment. The degree to which an internally generated rhythm is affected by environmental factors varies with the species and the function being controlled. The ease with which a function adjusts its rhythm to environmental cues will determine the degree to which the timing of that function can be altered. In humans, this has direct implications for the ability of the body clock to readjust following changes in schedules.

Circadian Rhythms

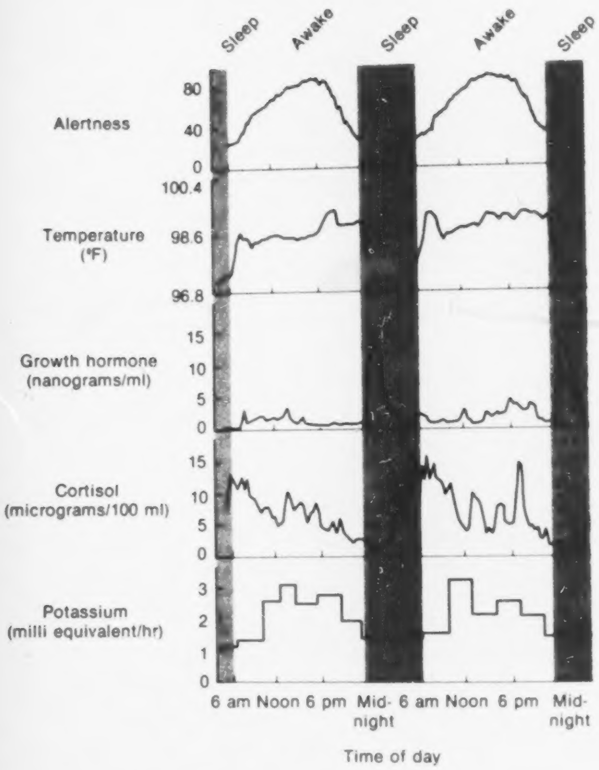
While biological rhythms have cycles ranging in length from minutes to months, those in synchrony with the 24-hour rotation of the Earth are probably the most extensively studied. These circadian rhythms are usually 20 to 28 hours long, and many physiological and psychological functions follow such a circadian cycle (figure 2-1).

Recognition that the activities of many plants and animals exhibit rhythms which coincide with the 24-hour cycle of day and night probably dates back to humanity's earliest contemplation of the temporal order of nature. The realization that these cycles were not solely a consequence of environmental

Photo credit: Dennis de Cicco/Sky & Telescope Magazine

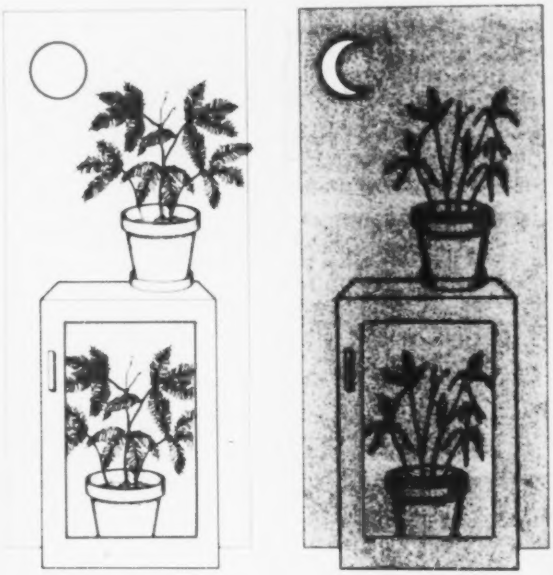
In each time zone, the daily rising of the Sun synchronizes internal clocks throughout the ecological community.

Figure 2-1—Circadian Timing of Various Functions



The timing of some functions that cycle with a circadian rhythm.
SOURCE: Adapted from R.M. Coleman, *Awake at 3:00 a.m. by Choice or by Chance* (New York, NY: W.H. Freeman, 1986).

Figure 2-2—De Mairan's Experiment



De Mairan observed a biological rhythm in plants.
SOURCE: R.M. Coleman, *Awake at 3:00 a.m. by Choice or by Chance* (New York, NY: W.H. Freeman, 1986).

influences did not occur until 1729, when French astronomer Jacques d'Ortous de Mairan studied the actions of a plant that normally opens its leaves during the day and closes them at night (figure 2-2). De Mairan observed that even when kept in the dark, the plant opened and closed its leaves according to the day-night cycle. This indicated that the force driving the plant's rhythms was internally generated (5).

The first observations of circadian rhythms in humans were made in 1866, when William Ogle noted that fluctuations in body temperature varied in synchrony with day and night (5). It was not until more recent times that the endogenous nature of circadian rhythms in humans was characterized (1). To date, research has identified hundreds of biological variables in humans that exhibit a circadian rhythm (5). These functions are both physiological (e.g., body temperature, hormone production, sleep-wake cycles) and psychological (e.g., cognitive performance, memory).

BIOLOGICAL RHYTHMS AND THE WORKPLACE

Humans are diurnal, and for most of history they obeyed the body clock's mandate to be active during the day and sleep at night. However, as civilization evolved, the desire, ability, and need to contravene this pattern of activity grew. The control of fire enabled humans to penetrate the darkness and explore the nighttime world. Since then, technological advances have led the way to societies whose activities extend beyond the daylight hours. This trend was accelerated with the Industrial Revolution and the advent of readily available electric power. In the last few decades, other technological and economic forces, such as the need to operate costly equipment continuously, the requirement of some manufacturing processes for uninterrupted operation, and the increasing demand for 24-hour serv-

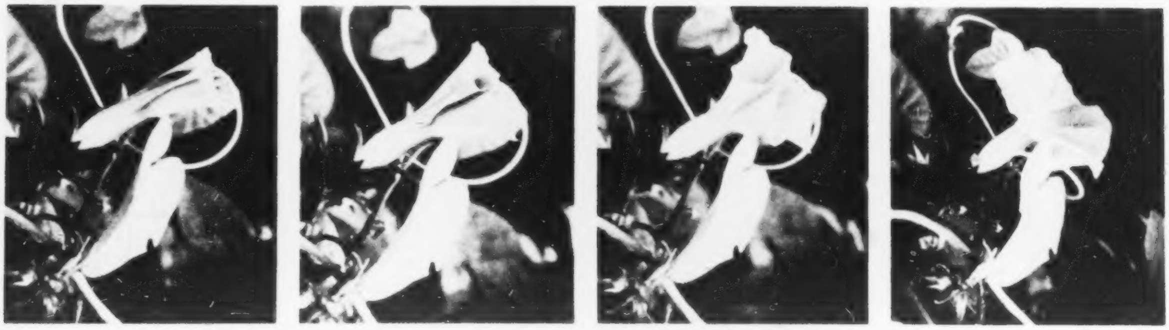


Photo credit: Travis Amos

Flowering in the morning glory, as in many other plants, is timed by a circadian clock.

ices, have contributed to the ever-growing number of occupations that operate around the clock.

As a result, many persons in these occupations work nonstandard schedules that can put them out of synchrony with their body clocks. The term "shift work" is often applied to these schedules, but there is no consistent definition of the term. In this report, it includes evening and night work; split shifts, in which a period of work is followed by a break and then a return to work; rotating shifts, in which the hours change regularly (e.g., from day to evening to night); and extended duty hours, consisting of long work periods (usually over 12 hours).

Many factors shape the experience of individuals working these schedules, and the interactions among them are complex (2-4,8). In addition to disrupting biological rhythms, shift work can cause other physiological factors, such as sleep deprivation and fatigue, to come into play. It can also affect the family and social life of workers, creating a situation in which their schedules do not coincide with those of the people around them. The cumulative effects of these factors can adversely affect the health and performance of workers and can jeopardize their safety and that of the public; however, the degree to which these effects occur, which workers are most susceptible, and the work conditions under which they occur have not been clearly delineated.

Many occupations require 24-hour operations. They include industrial and manufacturing industries (e.g., chemical, steel, paper, powerplants), protective and health services (e.g., police, fire and rescue, hospitals), transportation (e.g., airlines, railroads, trucking, shipping), major construction projects (e.g., dams, tunnels), and, increasingly, services (e.g., retail stores, financial institutions, entertainment and recreation, specialized services such as overnight deliveries). It is estimated that one in five workers in the United States does not regularly work a standard daytime schedule (6). As a result, about 20 million workers are exposed to a wide range of schedules that differ in the duration of the work period, the hour of day, and the stability of the schedule. Each of these schedules has different effects on workers' biological rhythms and related factors as well.

FEDERAL GOVERNMENT OVERSIGHT

In the United States, the laws that govern hours of work consist of the Fair Labor Standards Act, which was enacted in 1938 and established a standard 40-hour workweek, and various hours of service acts, which regulate maximum hours of work for a number of industries, notably transportation. In addition, some States have regulations regarding hours of work.

The Federal Government has broad authority to regulate working conditions that endanger the safety and health of workers through the Occupational Safety and Health Administration (OSHA) of the Department of Labor. In addition, some Federal agencies have the authority to regulate safety and health within their own jurisdiction. Examples of agencies that have exercised some authority over safety and health issues include the Federal Highway Administration, the Nuclear Regulatory Commission, and the Federal Aviation Administration.

OSHA can address worker safety and health issues by issuing standards that require employers to put in place appropriate protective measures and by inspecting for compliance. Where standards are not available, OSHA can act to increase safety and reduce health risks by enforcing the general duty clause of the Occupational Safety and Health Act. This requires employers in an industry that recognizes the existence of a serious hazard to take feasible steps to reduce the risk of that hazard to workers. OSHA can impose standards and regulations on the workplace when scientifically valid research and empirical data indicate that conditions impose a significant risk of harm to workers.

In the case of biological rhythms and their interaction with work schedules, the collection of data takes a number of forms, including basic scientific information on underlying biological mechanisms; applied research examining the human response in laboratory and field settings; and statistical information on the occurrence of injuries, mishaps, deaths, and health problems in the workplace and the conditions under which they occur, as well as demographic statistics on schedules being worked. The Federal Government's role in the collection of this information cuts across all of these. Federally funded extramural and intramural basic science research programs, through agencies such as the National Institutes of Health and the Air Force Office of Scientific Research, are a means of providing information on basic biological mechanisms. Federal or federally sponsored applied research programs can be conducted under the auspices of agencies such as the Centers for Disease Control (through the National Institute for Occupational Safety and Health) or other agencies, such as the National Aeronautics and Space Administration, the Department of Transportation, the Department of Defense, and the Nuclear Regulatory Commission. Collection of workplace statistics is done by OSHA and the Bureau of Labor Statistics within the Department of Labor.

Concerns about the effects of various work schedules on the health and safety of workers and the impact they could have on the public raise questions about the level of Federal involvement in the regulation of work hours and the types of schedules employed in various occupations. This concern is coupled with questions regarding the extent of knowledge about work schedules and their effects. In 1984, the Subcommittee on Investigation and Oversight of the Committee on Science and Technology of the U.S. House of Representatives held hearings on biological rhythms and shift work scheduling. It is interesting to note that many questions posed at that time still await answers, namely:

- What types of schedules are being worked and by whom?
- What are the precise effects on the health, performance, and general well-being of workers who work nondaytime hours?
- What kinds of effects occur in what kinds of schedules?
- Who are the workers who may be most affected?
- What factors contribute to any effects that are observed and to what degree?
- What are the implications of these effects for worker safety and the safety of the public?
- Most important, is enough known at this time to recommend specific guidelines or regulations?

This report discusses the current theories and ideas that pertain to these questions and describes the latest developments in the effort to answer them.

THE OTA REPORT

The primary focus of this report is the human body clock and what occurs when it is disrupted by various types of work schedules. In the seven chapters that follow, the Office of Technology Assessment (OTA) examines possible interactions of work schedules and biological rhythms and their implications for the American worker and the public. In addition, OTA examines the role of Congress and the Federal Government in addressing the public policy issues raised by this topic.

Chapter 3 reviews the most recent developments in understanding the body clock. It presents basic scientific information about biological rhythms, how they are regulated by the body, and how extrinsic factors can affect their functioning. In chapter 4, the forces driving the use of nonstandard work schedules are presented, as is a description of the population of U.S. workers who work them. Chapter 5 examines what can occur when work schedules impinge on the normal activity of the body clock. How disruption of biological rhythms interacts with other factors to affect the health, performance, and well-being of workers is described. The implications of these effects for the public's safety and possible interventions to counteract them are also addressed. Chapter 6 discusses the Federal role in regulating work hours and overseeing worker health and safety. Finally, in order to highlight the variety of settings in which nonstandard work hours can be encountered, OTA has selected three case studies to examine in closer detail. These case studies also represent occupations in which any adverse effects of nonstandard work hours that occur may affect the public welfare:

- nuclear powerplant control room operators (ch. 7),
- registered nurses and resident physicians (ch. 8), and
- the military (ch. 9).

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Chapter 3

Circadian Rhythms

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Chapter 3

Circadian Rhythms

Many biological functions wax and wane in cycles that repeat each day, month, or year. Such patterns do not reflect simply an organism's passive response to environmental changes, such as daily cycles of light and darkness. Rather, they reflect the organism's biological rhythms, that is, its ability to keep track of time and to direct changes in function accordingly. **Biological rhythms that repeat approximately every 24 hours are called circadian rhythms** (from the Latin *circa*, for around, and *dies*, for day) (61) (figure 3-1).

Human functions, ranging from the production of certain hormones to sleep and wakefulness, demonstrate circadian rhythms. This chapter summarizes the basic properties of circadian rhythms and addresses the following questions:

- How are circadian rhythms generated?
- How are they influenced by the environment?
- What specific human functions display circadian rhythms?
- What implications do these rhythms have for health and performance?
- How can circadian rhythms be manipulated?

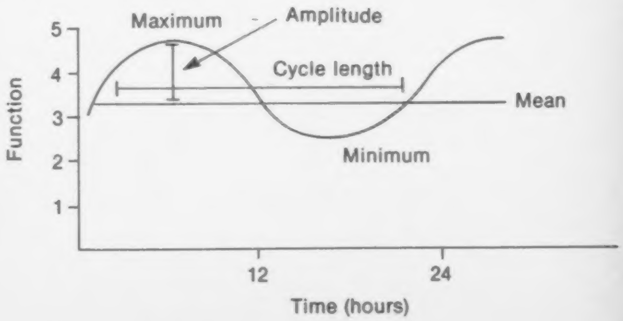
GENERAL PROPERTIES OF CIRCADIAN RHYTHMS

Circadian rhythms display several important characteristics. First, **circadian rhythms are generated by an internal clock, or pacemaker** (9,124). Therefore, even in the absence of cues indicating the time or length of day, circadian rhythms persist. The precise length of a cycle varies somewhat among individuals and species. Although organisms generate circadian rhythms internally, they are ordinarily exposed to daily cycles in the environment, such as light and darkness. **The internal clock that drives circadian rhythms is synchronized, or entrained, to daily time cues in the environment** (figure 3-2). Animal research has shown that only a few such cues, such as light-dark cycles, are effective entraining agents (12). In fact, the light-dark cycle is the principal entraining agent in most species, and recent research suggests that it is very powerful in synchronizing human circadian rhythms. The sleep-wake schedule and social cues may also be important entraining agents in humans.

An entraining agent can actually reset, or phase shift, the internal clock (12). Depending on when an organism is exposed to such an agent, circadian rhythms may be advanced, delayed, or not shifted at all. This variable shifting of the internal clock is illustrated in a phase response curve (PRC) (figure 3-3). PRCs were first derived by exposing organisms housed in constant darkness to short pulses of light (40,65,125). The organisms were isolated from all external time cues. When light pulses were delivered during the portion of the organism's internal cycle that normally occurs during the day (therefore called subjective day), they had little effect on circadian rhythms. In contrast, when light pulses were delivered late during the organism's nighttime, circadian rhythms were advanced. Light pulses delivered early during subjective night delayed circadian rhythms.

Several factors make it difficult to identify time cues that can reset the internal clock. First, there is no way to examine the function of the circadian pacemaker directly. The pacemaker's activity can only be evaluated through the circadian rhythms it drives, but unfortunately such functions are subject to other influences. Environmental stimuli may alter a particular circadian rhythm without disturbing the

Figure 3-1—Circadian Rhythm



Circadian rhythms have a single cycle length of approximately 24 hours. The amplitude, a measure of the degree of variation within a cycle, is the difference between the maximum value and the mean.

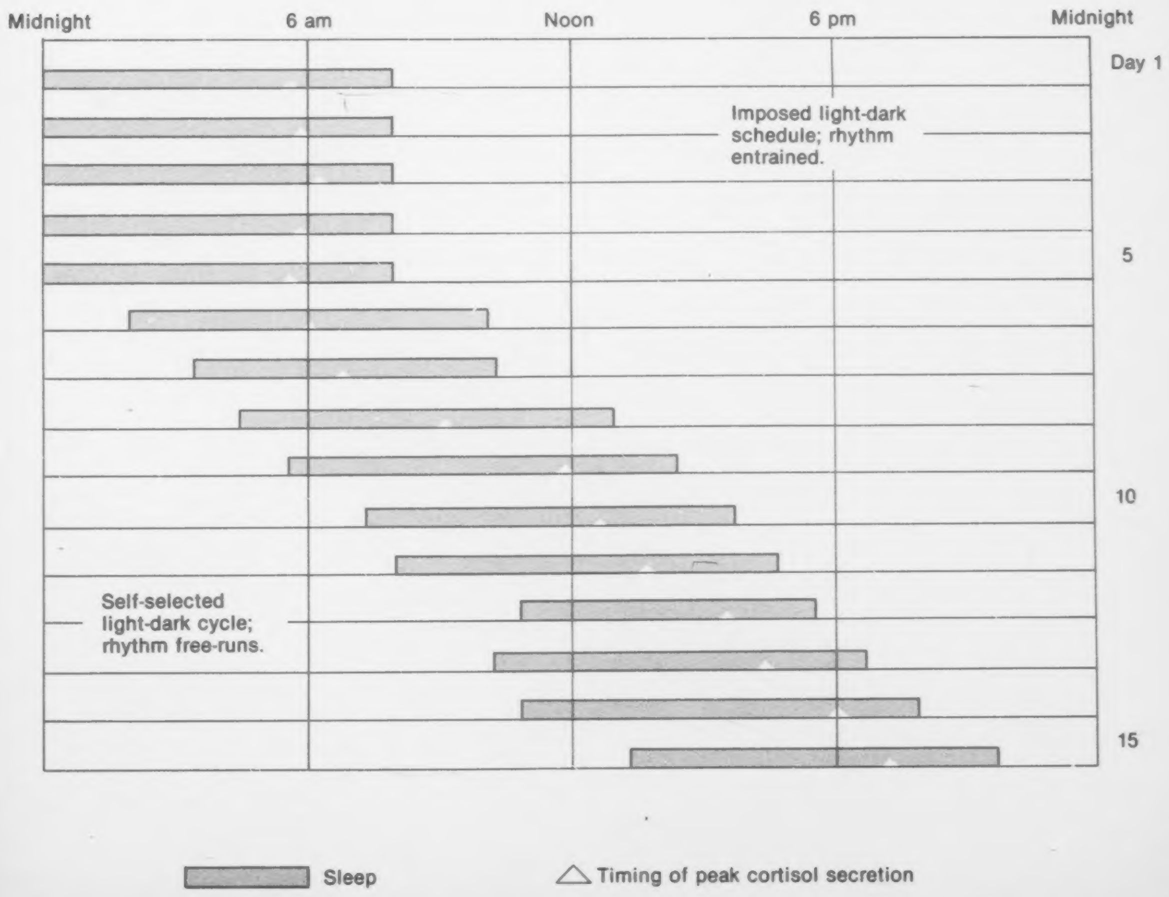
SOURCE: Office of Technology Assessment, 1991.

pacemaker at all. For example, going to sleep causes a temporary lowering of body temperature, without shifting the circadian cycle. Second, a function that exhibits a circadian rhythm may be controlled by both the circadian pacemaker and other systems in the body. For example, the timing and quality of sleep are controlled by circadian rhythms and other factors. Finally, classical techniques used to evaluate the pacemaker in animals and to generate a PRC involve complete isolation from all time cues (e.g., constant darkness) for several days, a difficult approach in human studies. Alternative methods for evaluating potential entraining agents in humans have been devised (see later discussion).

THE CELLULAR CLOCK

Circadian rhythms exist even in single cells. In fact, studies have shown that a wide range of cell functions exhibit circadian rhythms (159). Precisely how cells generate circadian rhythms is not known, but protein synthesis is critical to the process (50,168).

Figure 3-2—Synchronized and Free-Running Circadian Rhythms



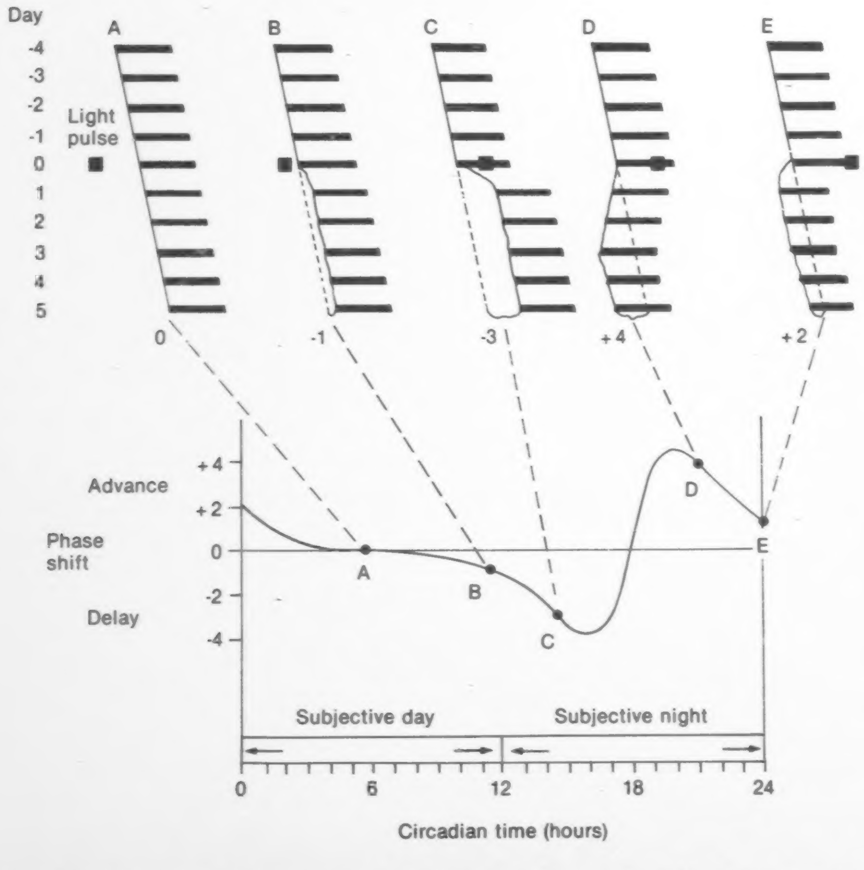
Plot of human sleep and maximum cortisol secretion when synchronized to the environment and when free of environmental input.

SOURCE: Adapted from G.S. Richardson and J.B. Martin, "Circadian Rhythms in Neuroendocrinology and Immunology: Influence of Aging," *Progress in NeuroEndocrinImmunology* 1:16-20, 1988.

Specific genes code for circadian rhythms. Genetic control of circadian rhythms has been examined most extensively in the fruit fly (*Drosophila melanogaster*), an organism that has played a key role in the study of genes and inheritance (63,76,142). Initially, painstaking studies were conducted, using chemicals that cause genetic mutations to alter circadian rhythms (77). It was found that mutations on the X chromosome disrupted the fruit fly's circadian rhythms by accelerating, slowing, or eliminating them. A specific gene on the X chromosome, called the per gene, has been identified, cloned, and characterized (15,25,64,202).

Other genetic mutations influencing circadian rhythms have been identified in the fruit fly (71), and genes other than the per gene have been found to control circadian rhythms in other species. The frq gene, for example, controls circadian rhythms in bread mold (*Neurospora crassa*) (52,63). A genetic mutation altering circadian rhythms in hamsters has been identified (131). In these experiments, a mutant

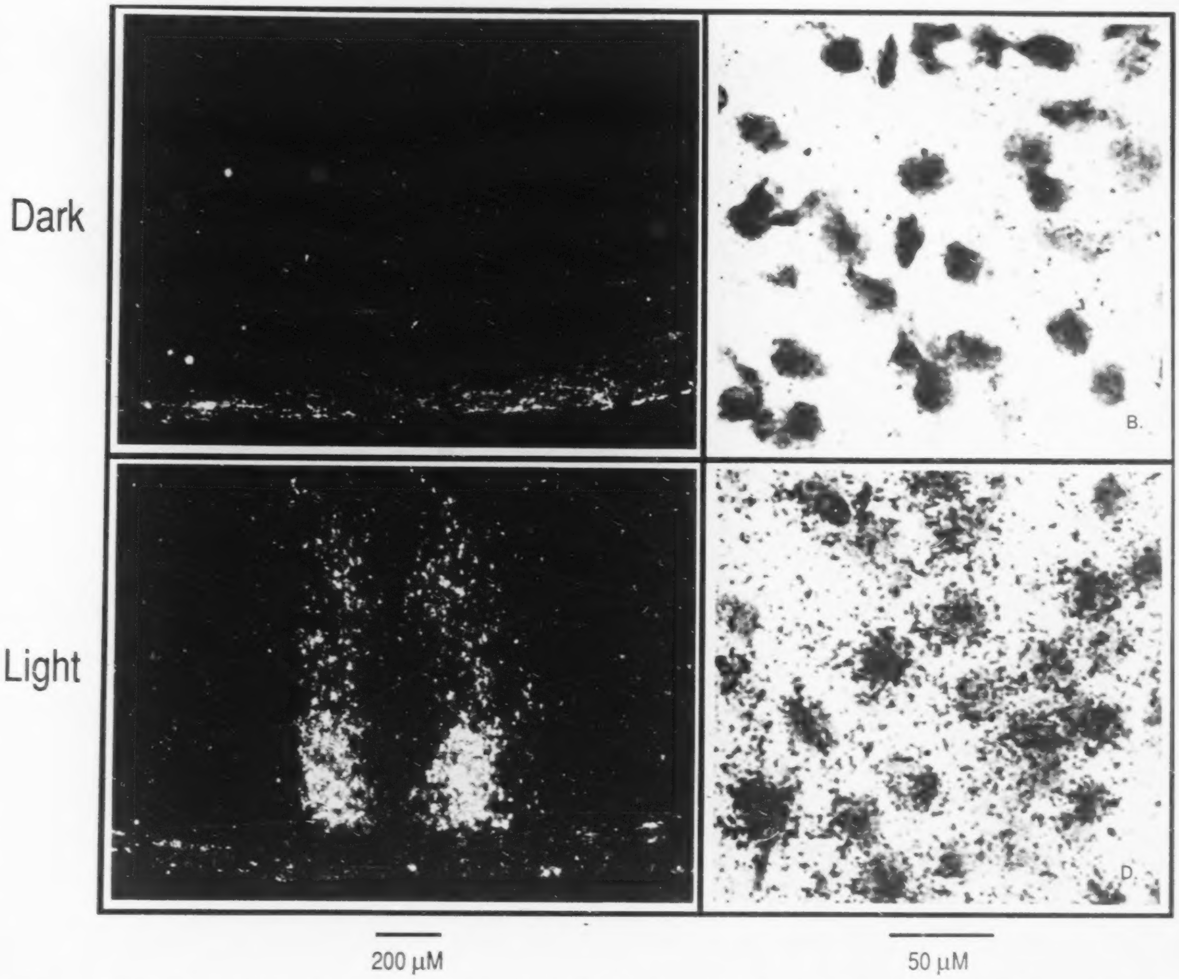
Figure 3-3—Phase Response Curve



Experiments demonstrate that exposure to light at different points in a single circadian cycle variably shifts the internal pacemaker (A-E). The pulse of light given in mid-subjective day (A) has no effect, whereas the light pulses in late subjective day and early subjective night (B and C) delay circadian rhythms. Light pulses in late subjective night and early subjective day (D and E) advance circadian rhythms. In the lower panel, the direction and amount of phase shifts are plotted against the time of light pulses to obtain a phase response curve.

SOURCE: M.C. Moore-Ede, F.M. Sulzman, and C.A. Fuller, *The Clocks That Time Us* (Cambridge, MA: Harvard University Press, 1982).

Figure 3-4—Gene Expression in the Pacemaker



Photographs from the pacemaker (the suprachiasmatic nucleus) of hamsters housed in darkness (A and B) or following a pulse of light (C and D). The silver grains indicate the activation of the c-fos gene. Data show that exposure to light that would reset circadian rhythms stimulates the c-fos gene.

SOURCE: J.M. Kornhauser, D.E. Nelson, K.E. Mayo, et al., "Photic and Circadian Regulation of c-fos Gene Expression in the Hamster Suprachiasmatic Nucleus," *Neuron* 5: 127-134, 1990.

gene was linked to a shortened circadian cycle. Finally, recent research has implicated the c-fos gene in resetting the internal clock (figure 3-4) (see next section).

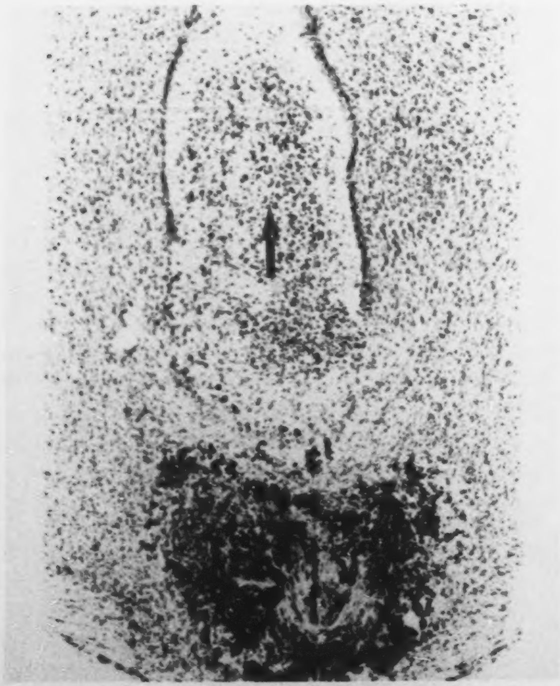
THE PACEMAKER IN THE BRAIN

The circadian rhythms of various functions in humans, such as hormone production, body temperature, and sleepiness, are normally coordinated—i.e., they bear a specific relationship to each other. This temporal organization suggests that some biological timekeeping device must drive, regulate, or at least integrate various circadian rhythms. In mammals, considerable experimental evidence indicates that **a region of the brain called the suprachiasmatic nucleus (SCN) is the circadian pacemaker** (98). The SCN, composed of a cluster of thousands of small nerve cells, is located within a region of the brain, the hypothalamus, that controls such basic functions as food intake and body temperature.

Various lines of evidence pinpoint the SCN as the primary mammalian pacemaker. Nerve cells in the SCN can generate circadian rhythms when isolated from other areas of the brain (59,60,70,98,136, 147,158,161,180). The integrity of the SCN is necessary for the generation of circadian rhythms and for synchronization of rhythms with light-dark cycles (70,185). Compelling evidence that the SCN functions as the primary circadian pacemaker comes from animal studies of SCN transplantation (41,48,83,129,155). In these experiments, the SCN is destroyed, abolishing circadian rhythms. When fetal brain tissue containing SCN nerve cells is transplanted into the brains of these animals, circadian rhythms are restored (129) (figure 3-5).

Light in the environment influences mammalian circadian rhythms by synchronizing the SCN. Light activates cells in the eye, which in turn activate the SCN (122,149,154). Recent animal experiments have shown that light activates the c-fos gene within cells in the SCN (figure 3-4) (79,132,150). The c-fos gene is a proto-oncogene, which is associated with growth, stimulation of nerve cells, and, in pathological conditions, tumor formation.

Figure 3-5—The Transplanted Pacemaker



Photograph of transplant of fetal hamster suprachiasmatic nucleus (arrow) into the brain of an adult hamster.

SOURCE: P.J. DeCoursey and J. Buggy, "Circadian Rhythmicity After Neural Transplant to Hamster Third Ventricle: Specificity of Suprachiasmatic Nuclei," *Brain Research* 500:263-275, 1989.

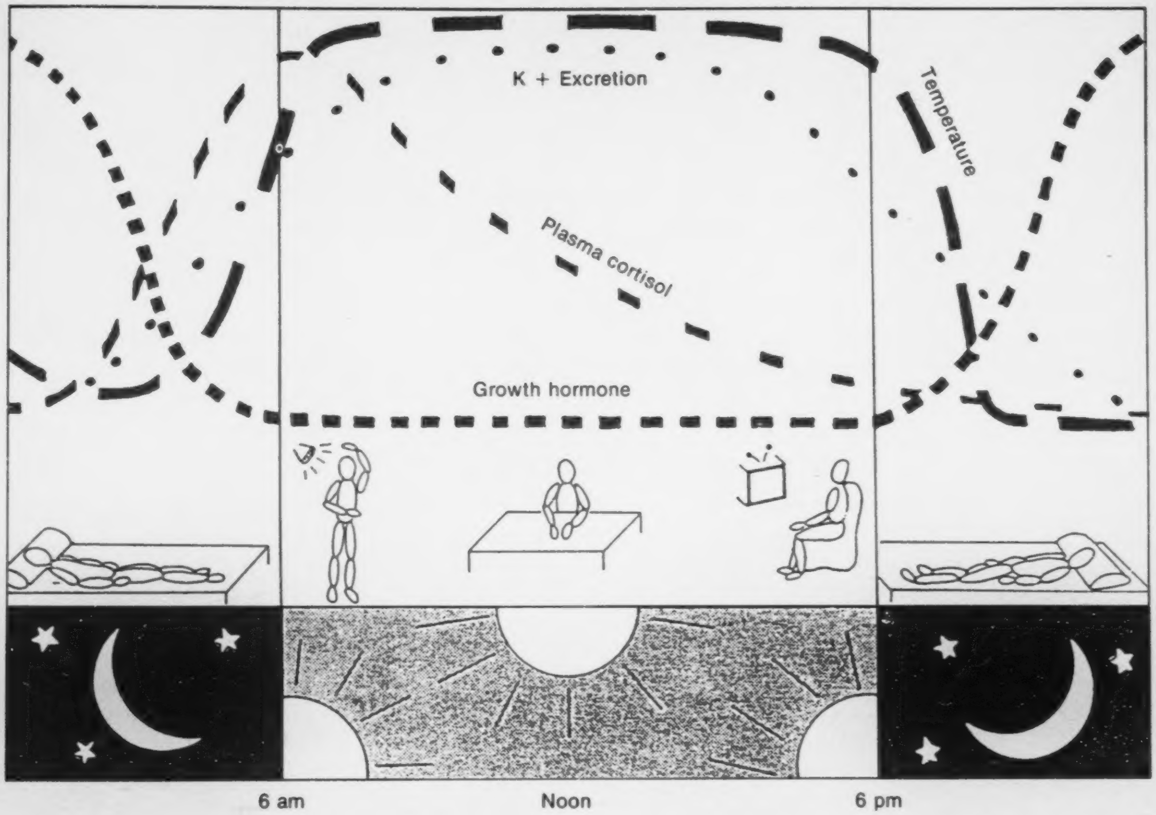
It is clear that the SCN serves as the primary circadian pacemaker in mammals, but there are still many unknowns concerning its activity. How does the SCN, with its tens of thousands of nerve cells and a wide variety of brain chemicals, generate circadian rhythms? How does the SCN coordinate or drive overt circadian rhythms in the animal? Little is known about how the SCN interacts with other parts of the brain to generate and synchronize overt rhythms. Is the SCN the only circadian pacemaker in mammals? There is evidence that other areas of the nervous system produce circadian rhythms. For example, data suggest that cells in the mammalian eye are capable of generating circadian rhythms (135,169). Also, circadian rhythms of meal anticipation and temperature have been reported to persist despite destruction of the SCN (147).

HUMAN CIRCADIAN RHYTHMS

Consider the following reported data: the frequency of heart attacks peaks between 6 a.m. and noon (117,140); asthma attacks are most prevalent at night (96); human babies are born predominantly in the early morning hours (57,73). While these patterns do not necessarily indicate that the events are driven by the circadian pacemaker, they do suggest temporal order in the functioning of the human body. This temporal organization appears to be beneficial; the human body is prepared for routine changes in state, such as awakening each morning, rather than simply reacting after shifts in demand (113) (figure 3-6). In addition, these regular cycles in the body present considerations for diagnosis of health problems and for the timing of medical treatment (62,102) (box 3-A).

Although daily fluctuations in various human functions have been documented for more than a century, that does not prove that they are controlled by the circadian pacemaker. Not until individuals were examined in temporal isolation could human circadian rhythms be verified. The first studies sequestering humans from all time cues were reported in the early 1960s (10). During the course of these and other studies, which lasted days, weeks, and even months, individuals inhabited specially designed soundproof and lightproof rooms that

Figure 3-6—Human Circadian Rhythms



Circadian rhythms of sleep, body temperature, growth hormone, cortisol, and urinary potassium in a human subject.

SOURCE: Adapted from G.S. Richardson and J.B. Martin, "Circadian Rhythms in Neuroendocrinology and Immunology: Influence of Aging," *Progress in NeuroEndocrinImmunology* 1:16-20, 1988.

excluded any indication of the time of day, such as clocks, ambient light, or social interactions. In this temporal vacuum, individuals were instructed to sleep and eat according to their bodies' clocks. These studies indicated that daily fluctuations in some human functions are generated by an internal clock (35,192). While these studies of humans isolated from time cues provide insight into the operation of the human circadian pacemaker, the approach presents difficulties; it is time-consuming and expensive, and it is difficult to recruit subjects for extended study. Alternative methods have been developed for evaluating human circadian rhythms, and these are discussed in subsequent sections.

In the following sections, an overview of various human circadian rhythms is presented, as are some medical implications (boxes 3-A and 3-B). Data on human sleep and performance rhythms, which are intimately related to shift work concerns, are discussed in detail.

The Body Circadian

Several hormones are secreted in a cyclic fashion (181). The daily surge of prolactin and growth hormone, for example, appears to be triggered by sleep (182,183). Sex hormones are secreted at varying levels throughout the day, the pattern of secretion reflecting the fertility, reproductive state, and sexual maturity of the individual. Secretions of glucose and insulin, a hormone important for regulating the metabolism of glucose, also exhibit circadian rhythms. Glucose concentrations in the

Box 3-A—Circadian Rhythms and Drugs

Since the human body is not static or constant in its function over time, its responses to drugs are likely to vary over time. Thus, not only the dosage, but also the timing of administration influences a drug's effects, both therapeutic and toxic. Chronopharmacology, the study of circadian rhythms and the timing of drug treatment, has important clinical implications.

From the time a drug is administered until it is eliminated from the body, it is acted on by many organs, including the intestines, the cardiovascular system, the liver, and the kidneys. Absorption, distribution, and elimination of drugs—i.e., pharmacokinetics—are subject to circadian variation. A tissue's responsiveness to a drug, which may reflect the number of receptors, or binding sites, on target cells or their metabolic activity, also exhibits circadian rhythms. Changes in the effects of a drug when administered at different times over the course of a 24-hour period stem from the circadian variation in pharmacokinetics and tissue responsiveness. Proper timing of drug administration can enhance its therapeutic actions and diminish unwanted side effects.

The most advantageous schedule of administration must be determined for each drug. Even drugs with only slight differences in structure may be handled differently by the body. For example, injection of the anticancer drug adriamycin into the abdomen of rats leads to toxic effects on bone marrow; intravenous injection has toxic effects on the heart. Different scheduling of these two modes of adriamycin injection significantly reduced these side effects. Ideally, the administration of drugs in clinical situations should be adapted to each patient's circadian rhythms.

The main reason to consider circadian rhythms when timing drug administration is the balance between the toxicity of a compound and its therapeutic effects. Anticancer drugs are the most prominent example. Many anticancer drugs currently in use kill replicating cells—all replicating cells, malignant or not. The side effects associated with these drugs generally limit the amounts that are administered, seriously restricting their effectiveness. Attempts to minimize the toxic side effects of anticancer drugs, thus permitting increased doses, presumably with improved effectiveness against the disease, lie at the root of the search for an optimal drug delivery schedule.

Optimal drug delivery schedules for more than 20 anticancer agents have been determined in animal studies. Furthermore, the action of newer agents, including tumor necrosis factor and interleukin-2, has demonstrated a sensitivity to circadian rhythms. Studies have also been implemented to determine the optimum timing of anticancer drugs used in combination, a common medical practice for the treatment of cancer.

The chronopharmacology of several anticancer agents has been studied in humans. Specific therapies evaluated include the agents 5-fluoro-2-deoxyuridine (FUDR) for the treatment of metastatic adenocarcinoma and the combination of doxorubicin and cisplatin for ovarian and bladder cancer. The regimens chosen were found to diminish side effects significantly and in some cases to extend survival time. FUDR was delivered by an automatic pump, which can be programmed to release drugs at a variable rate over time. This device is surgically implanted in the patient and can be noninvasively programmed by an external computer. Drug supplies in the pump are replenished via simple injection. In general, clinical studies to date, while preliminary, suggest that by carefully timing the administration of anticancer drugs, their therapeutic effects may be improved, toxic effects diminished, or both.

SOURCE: Office of Technology Assessment, 1991.

blood peak late at night or early in the morning (181), and insulin secretion peaks in the afternoon (118).

The secretion of cortisol, a steroid hormone important for metabolism and responses to stress, fluctuates daily, peaking in the very early morning hours and falling to a negligible amount by the end of the day (181). Besides its use as a marker for the internal pacemaker, the circadian rhythm of cortisol secretion may drive other rhythms in the body and has important clinical implications. For example, blood tests used to diagnose suspected excess cortisol production will be most sensitive during the evening. Also, cortisol-like steroid hormones used therapeutically to treat asthma and allergies and to suppress the immune system, are best administered in the morning, when they interfere least with the body's own cortisol production.

Circadian rhythms in cardiovascular function have long been recognized. Indicators of heart and

Box 3-B—Cycles That Last From Minutes To Days

Circadian rhythms are a basic and well-recognized feature of human physiology and behavior. However, biological rhythms that repeat more or less frequently than every 24 hours are also fundamental to the body's function. In general, ultradian rhythms (those with a length of less than 24 hours) and infradian rhythms (those with a length greater than 24 hours) do not coincide with conspicuous environmental cues, and how they are generated is not well understood.

Sleep cycles were one of the first ultradian rhythms characterized in humans. A complete cycle of dreaming and nondreaming takes place about every 90 minutes. This finding prompted researchers to hypothesize that cycles of enhanced arousal followed by diminished activity typify both waking and sleeping periods. This theory of a basic rest-activity cycle has led to many studies of ultradian cycles in alertness-sleepiness, hunger, heart function, sexual excitement, urine formation, and other functions.

Hormones are also released in ultradian cycles. Many are secreted in a more or less regular pattern every few hours. More frequent cycles of release, every few minutes, have also been documented. Although the mechanisms of hormone secretion have not been uncovered, patterned release has been shown to be extremely important for proper functioning. For example, experiments have shown that, when replacing a deficient hormone, pulses of the hormone, not a continuous supply, are required for effectiveness. Also, abnormalities in the production cycle of hormones have been correlated with altered function. Although these cycles do not appear to be tightly coordinated, it is clear that ultradian rhythms with a cycle of 90 minutes, as well as with cycles of a few minutes to several hours, are a basic component of many human functions. How they are generated is unknown.

The most prominent infradian rhythm in humans is the menstrual cycle. Through a series of complex interactions between the brain and reproductive organs, an egg is released by an ovary approximately every 28 days, and the reproductive organs are prepared for possible fertilization. During each cycle, hormones are secreted in varying amounts, and the reproductive tract and breast tissue are altered. Other systems, such as those involved in immune function, may also be affected.

Although the menstrual cycle has long been recognized, how it is generated and how it interacts with other factors have not been completely detailed. It is clearly affected by circadian rhythms. For example, a peak in the secretion of luteinizing hormone, which triggers ovulation, usually occurs in the early morning hours. Also, phase shifts, such as those produced by transmeridian flight, may interfere with the menstrual cycle. The menstrual cycle may also have therapeutic implications. A recent study of the timing of breast cancer surgery in relationship to the menstrual cycle has found fewer recurrences and longer survival in patients whose surgery occurred near the middle of the menstrual cycle rather than during menstruation. That biological rhythms are often ignored is also indicated in this study: less than half of the records evaluated in the study recorded the time of the last menstrual period.

SOURCE: Office of Technology Assessment, 1991.

blood vessel function that demonstrate daily rhythms include blood pressure, heart rate, blood volume and flow, heart muscle function, and responsiveness to hormones (84). The daily fluctuations in cardiovascular function are further illustrated by symptoms of disease. Data have shown that abnormal electrical activity in the heart and chest pains peak at approximately 4 a.m. in patients suffering from coronary heart disease (189,190). As stated earlier, the number of heart attacks has been shown to peak between 6 a.m. and noon (117,140). These temporal characteristics of cardiovascular disease indicate the importance of careful timing in their assessment, monitoring, and treatment (120).

The widely recognized pattern of nighttime increases in asthma symptoms highlights the circadian rhythms of the respiratory system. Which respiratory functions are responsible for nocturnal asthma symptoms? Exposure to allergy-producing substances, the respiratory system's responsiveness to compounds that can initiate an asthma attack, daily changes in the secretion of certain hormones, cells in the lung and blood that may be important mediators of asthma, and the recumbent position have all been suggested as possible mechanisms (16,163). The prevalence of asthma attacks at night has led to drug treatment approaches that take circadian rhythms into account.

Other organ systems also reveal circadian fluctuations. Kidney function and urine formation vary over the course of a 24-hour period; there are daytime peaks in the concentrations of some substances in the urine (sodium, potassium, and chloride) and nighttime peaks in others (phosphates and some acids) (78). Urine volume and *p*H also peak during the day. Immune system and blood cell functions cycle daily, as do cell functions in the stomach and intestinal tract (85,112).

The Timing of Sleep

Daily cycles of sleep and wakefulness form the most conspicuous circadian rhythm among humans. Traditionally, about 8 hours each night are devoted to sleep. While neither the function of sleep nor how it is regulated is completely understood, it is clear that sleep is a basic requirement that cannot be denied very long. Even a modest reduction in sleep leads to decrements in performance, especially at night. Furthermore, when deprived of a night or more of sleep, individuals can find sleep impossible to resist, especially in monotonous situations, and they experience brief episodes of sleep, called microsleeps (45,104).

Classic studies indicate that sleep is not a homogeneous state (42,75). Polysomnography, the measurement of electrical activity in the brain, eye movement, and muscle tone, has revealed distinct stages of sleep (table 3-1). During stages 1 through 4, sleep becomes progressively deeper. In stages 3 and 4, which constitute slow wave sleep (SWS), the eyes do not move, heart rate and respiration are slow and steady, and muscles retain their tone but show little movement. Dreams are infrequent. As sleep continues, dramatic changes occur: brain activity appears similar to that seen during wakefulness, heart rate and respiration increase and become erratic, dreams are vivid and frequently reported, and the eyes move rapidly. This stage of sleep is rapid eye movement (REM) sleep. Typically, cycles of non-REM sleep (stages 1 through 4) and REM sleep repeat every 90 to 100 minutes throughout the course of a night's sleep.

When synchronized to the 24-hour day, the timing of sleep usually bears a characteristic relationship to the environment and to other circadian rhythms in the body. In general, humans retire for sleep after dark, when body temperature is falling. Morning awakening coincides with an upswing in body temperature. With the exception of an occasional afternoon lull (box 3-C), wakefulness continues throughout the day, and body temperature reaches its zenith during the late afternoon.

Studies of humans isolated from all time cues have unveiled several characteristics about the timing of the sleep-wake cycle and the circadian pacemaker. In isolation, circadian rhythms are approximately 25 hours long (figure 3-7). While the sleep-wake and body temperature cycles are a similar length at first, their relationship gradually changes, until body temperature decreases during wakefulness and increases during sleep (34,35).

Prolonged temporal isolation, for many days or weeks, sometimes leads to a dramatic dissociation of

Table 3-1—Differences Between Rapid Eye Movement (REM) Sleep and Slow Wave Sleep (SWS)

Factors concerning sleep	REM sleep	SWS (stages 3 and 4)
Brain		
Measured activity	High	Low
Cerebral blood flow	High	Low
Oxygen consumption	High	Low
Temperature	High	Low
Body		
Eyes	Rapid movements	No movements
Pupils	Dilated	Normal
Heart rate	Increased and variable	Slow and steady
Respiration	Increased and variable	Slow and steady
Behavior		
Movements	Occasional twitches	None
Dream reports	Frequent and vivid	Infrequent and vague
Deprivation	Agitated and impulsive	Withdrawn and physical complaints

SOURCE: Office of Technology Assessment, adapted from D.F. Dinges, "The Nature and Timing of Sleep," *Transactions & Studies of the College of Physicians of Philadelphia* 6:177-206, 1984.

Box 3-C—Napping

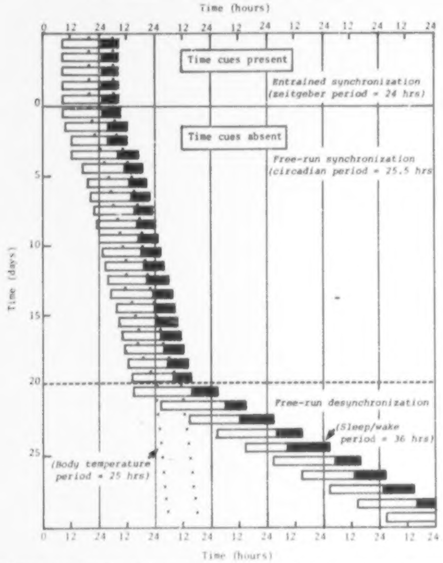
Are human beings biologically programmed to nap? Divergent lines of evidence, both direct and indirect, suggest that midafternoon napping is an inherent aspect of human behavior. No other species exhibits exclusively once-a-day, or monophasic, sleep patterns. Indeed, as children develop, the midafternoon nap is generally relinquished only when school interferes. Adult napping is more prevalent than most Americans realize, especially in other cultures and among persons who may be sleep-deprived. More than 50 percent of all college students, for example, nap at least once a week. Napping also appears to increase among retired Americans.

There are other indications that a midafternoon nap is natural in humans. When human circadian rhythms are analyzed in a time-free environment, napping is common. The postlunch dip, or the midafternoon decrease in human performance regardless of food intake, may reflect a proclivity for sleep at that time. Decreased human performance presumably accounts for the midafternoon peak in traffic accidents. Moreover, the decline in human performance corresponds to peaks in sleepiness. Measures of sleepiness using the multiple sleep latency test demonstrate a more rapid onset of sleep in the afternoon. Pathological conditions, such as narcolepsy, or frequent, uncontrolled sleeping, also exhibit a midafternoon peak in sleep episodes.

Insight into human napping behavior may have some practical implications. While mood and subjective feelings of sleepiness may not be affected by napping, performance during extended periods of work can be improved. In addition, the scheduling of brief episodes of sleep during sustained periods of work may be optimized: research suggests that napping before, rather than after, extended periods of work is best for reducing the effects of sleep loss.

SOURCE: Office of Technology Assessment, 1991.

Figure 3-7—Human Circadian Rhythms in the Absence of Time Cues



An idealized example of human sleep-wakefulness and temperature rhythms in a time-free environment.

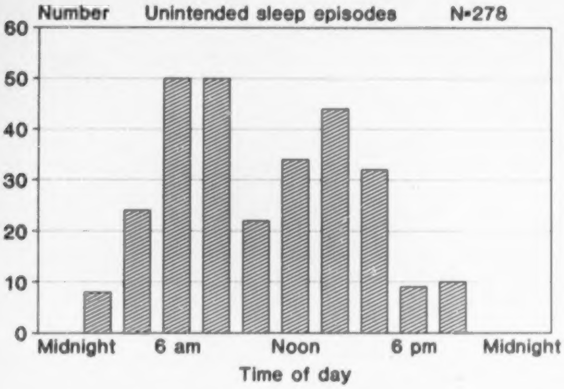
SOURCE: D. F. Dinges, "The Nature and Timing of Sleep," *Transactions & Studies of the College of Physicians of Philadelphia* 6: 177-206, 1984.

body temperature and sleep-wake cycles, a state called internal desynchronization (10) (figure 3-7). In some individuals, while the body temperature cycle maintains a 25-hour length, the sleep-wake cycle may become 30 to 50 hours long, with sleep occupying 6 to 20 hours per cycle. Despite the apparent lack of synchrony between sleep-wake and body temperature cycles, further studies show that a relationship is maintained between the two (34,204). REM sleep is more prevalent as body temperature rises. Similarly, wake times correlate to rising body temperature, regardless of when the sleep period began. Sleep is of short duration if it begins at the body temperature's low point; sleep is long if it begins near the peak of the body temperature rhythm, with wake time occurring at the next body temperature peak. These studies indicate that circadian rhythms influence total sleep time (165).

Other characteristics of the timing of sleep and wakefulness have been discerned. How long it takes to fall asleep in a sleep-promoting environment at different times throughout the day can be measured using the multiple sleep latency test. Studies using this technique have shown that individuals fall asleep most rapidly at two times, during the middle of the night and during the middle of the afternoon (figure 3-8) (19,138). Conversely, experiments have demonstrated that there are times during the course of the day when falling asleep is very difficult (81).

In summary, sleep is a necessary component of life. When synchronized to the 24-hour day, sleep typically occurs during the night hours and bears a constant, if complex, relationship to other circadian

Figure 3-8—Sleepiness During the Day



Episodes of unintentional sleep over the course of a day.

SOURCE: M.M. Mitler, M.A. Carskadon, C.A. Czeisler, et al., "Catastrophes, Sleep, and Public Policy: Consensus Report," *Sleep* 11:100-109, 1988.

rhythms. Particular components of sleep, including total amount of sleep and sleepiness, are governed by the circadian clock. Therefore, periods of sleep are not readily rescheduled, deferred, or resisted. The requirement for sleep and the control of its timing have important implications for work schedules and shift work (see ch. 5).

Human Performance

Physiological variables such as body temperature, hormone levels, and sleep are not the only human functions that exhibit circadian rhythms. Human performance, including psychological processes and mental functions, also exhibits circadian fluctuations (26). Diverse components of human performance, including memory, reaction time, manual dexterity, and subjective feelings of alertness, have been dissected experimentally to ascertain when they peak during the course of a day and how they are affected by circadian rhythm disruption.

Research conducted during the first half of this century indicated that some aspects of human performance improve over the course of the day, climaxing when peak body temperature is achieved. Subsequent experiments determined that the timing of peak performance varied with the nature of the task being assessed. **Several factors, including perceptual involvement, the use of memory, and the amount of logical reasoning required, appear to be important in determining when particular types of performance peak during the circadian cycle.** Performance of tasks involving manual dexterity, simple recognition, and reaction time appears to parallel the circadian rhythm of body temperature, peaking when body temperature is highest, in the late afternoon (54,107,110,111). Verbal reasoning seems to peak earlier in the circadian cycle and may adjust more quickly than other types of performance to such disruptions as jet lag (box 3-D) (69,107, 110,111). An individual's assessment of mood and alertness also exhibits circadian rhythms. For example, when subjects are asked to indicate their level of alertness, weariness, happiness, or other moods on a visual scale at regular times throughout the course of the day, consistent circadian patterns emerge (figure 3-9) (54,106,108,109,173).

Variation in performance may also reflect subtle differences between tasks and the way in which a task is approached (53). For example, when subjects were asked to identify the larger of two spheres, it was found that, if speed of identification was assessed, the usual relationship with temperature held—that is, subjects became faster over the course of the day. However, if accuracy of response became the benchmark, peak performance occurred in the morning (27,107). Short-term and long-term memory also appear to peak at different times during the 24-hour cycle (53). Motivation can influence performance, too. It has been shown that when an incentive is offered, such as a significant sum of money, circadian decrements in performance may be overcome to some extent (26,68). The latter study (68) indicated, however, that sleep deprivation and circadian rhythms can overcome even the strongest incentive influencing performance. Further complicating the picture is the observation that individuals are not always accurate judges of their own mood, alertness, or ability. For example, a short nap may be able to counteract decrements in performance caused by lack of sleep without alleviating subjective feelings of sleepiness (56).

Many aspects of human performance decline to minimal levels at night, reflecting not only the influence of the circadian pacemaker, but also the lack of sleep (14). Sleep deprivation, even for one night, is one of the most important disrupting factors of human mental and physical function (46). Sleep loss influences several aspects of performance, leading to slowed reaction time, delayed responses, failure to respond when appropriate, false responses, slowed cognition, diminished memory, and others.

Box 3-D—Jet Lag

Transmeridian air travel, especially across several time zones, can severely disrupt circadian rhythms. It may produce an unpleasant and somewhat disabling constellation of symptoms collectively labeled jet lag. Jet lag varies among individuals and may include trouble sleeping, daytime sleepiness, gastrointestinal disruption, and reduced attention span. Physical and mental performance may also be seriously diminished following transmeridian flight.

What precipitates jet lag? Stress and loss of sleep associated with air travel certainly contribute to postflight fatigue; however, these factors alone do not interrupt circadian rhythms. Rather, conflict between the traveler's own circadian clock and external rhythms in a new time zone is the primary agent of jet lag. The timing of meals, activity, and sleep no longer coincides with that customary in the new time zone. Furthermore, environmental cues, especially light, promote synchronization between circadian rhythms and the new time zone. Since different circadian rhythms may adjust to the new time zone at different rates, the air traveler experiences a period when internally generated rhythms are no longer in synchrony with each other. The lack of synchrony between internal and external rhythms, as well as among different internal rhythms, probably results in the malaise and diminished performance associated with jet lag.

How long it takes to adjust to a new time zone and recover from jet lag depends on several factors, including the number of time zones crossed, the direction of travel, differences among individuals, age, and the particular circadian rhythm involved. The number of time zones crossed, or hours phase shifted, significantly influences the occurrence and duration of jet lag; resetting the circadian system can take as many as 12 days following a 9-hour flight across several time zones. Even a 1-hour time shift can require at least a day for complete adjustment.

The direction of air travel may also influence the severity of jet lag. Most, but not all, studies indicate a more rapid adjustment to westward than to eastward travel. Also, the severity and duration of jet lag vary markedly among individuals. One rule of thumb is that persons with less variable body temperature rhythms become synchronized to a new time zone more rapidly. (Older persons, who may exhibit a reduction in circadian variation, generally have more difficulty adjusting to a new time zone.) What mechanisms determine how quickly phase shifts occur is not known. As mentioned, various circadian rhythms adjust to external cues at various rates. For example, it may take 2 days for the sleep-wake cycle to adjust to a 6-hour time zone shift but 5 or more days for body temperature rhythm to be entrained. Furthermore, recovery from jet lag may not proceed linearly: some data indicate that sleep and performance may improve the first day following a phase shift and languish the next.

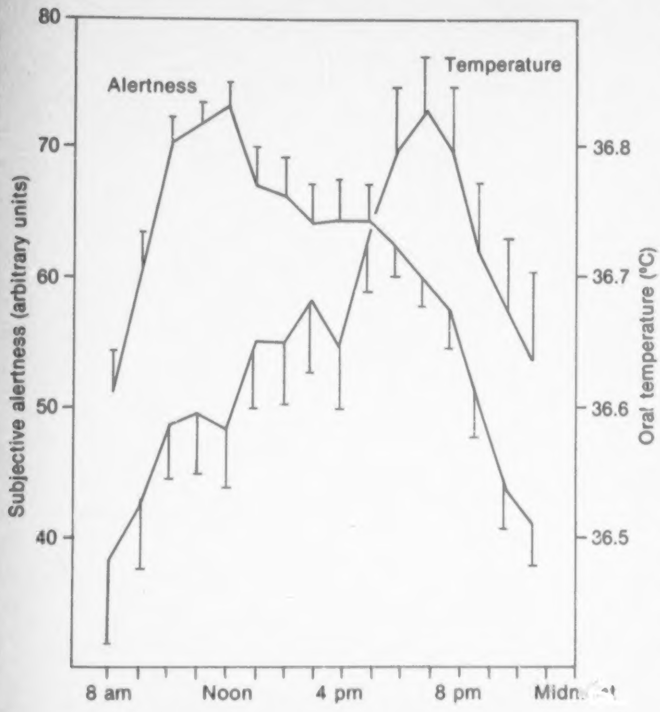
Measures to hasten adjustment to a new time zone, including the use of certain drugs, bright light, exercise, and diet, are under investigation. Improved understanding of human circadian rhythms has prompted recommendations from scientists about how best to confront jet lag. Short trips of only a few days across time zones probably do not warrant an attempt to adjust to the local time zone. In these situations, it is best to try to schedule activities and sleep as close to one's internal clock as possible in order to avoid jet lag. For longer trips, suggestions for resetting one's internal clock include adopting the new schedule immediately and maximizing exposure to environmental cues, especially light at specific times (figure 3-12). The problems are very complex for international air crews, who fly rapid sequences of transmeridian flights (see ch. 4) combined with irregular hours of work and rest. The kinds of jet lag countermeasures that may suffice for occasional transmeridian travellers (use of hypnotics, scheduled bright light exposure, and so on) are generally not practical—and may even be hazardous—for individuals exposed to repeated time zone changes. These issues are being addressed in a broad program of field and laboratory research being conducted by the Aviation Human Factors Branch at the National Aeronautics and Space Administration's Ames Research Center (see app. B).

SOURCE: Office of Technology Assessment, 1991.

The circadian clock also leads to a nighttime minimum in many types of performance (26,104). Thus, sleep deprivation combined with the influence of the circadian pacemaker can severely curtail performance at night. These factors have important implications for shift work (see ch. 5).

In summary, circadian rhythms can cause performance to vary according to the nature of the task or mood assayed. Other factors, such as fatigue and motivation, also profoundly influence human performance. Furthermore, a discrepancy may exist between an individual's own assessment of his or her ability to perform and the performance that is actually demonstrated. When individuals are synchronized to the natural day-night cycle, many types of performance reach minimum levels during the

Figure 3-9—Circadian Rhythms of Alertness



The circadian rhythms of subjective alertness and body temperature from persons synchronized to a 24-hour day.

SOURCE: T.H. Monk, M.L. Moline, J.E. Fookson, et al., "Circadian Determinants of Subjective Alertness," *Journal of Biological Rhythms* 4:393-404, 1989.

night, reflecting the combined influence of the circadian pacemaker and the lack of sleep.

DISRUPTION OF CIRCADIAN RHYTHMS

When rhythms generated by the body conflict with those in the environment, function is compromised until the rhythms are realigned. Patterns of sleep are disrupted, performance may be impaired, and a general feeling of malaise may prevail. Data linking disrupted circadian rhythms with some mental and sleep disorders also point to the importance of an intact circadian system for health. The following section discusses specific situations, other than shift work, that may be associated with altered or disrupted circadian rhythms. Shift work is discussed in chapter 5.

Aging and the Body Clock

Are circadian rhythms altered by the aging process? The stereotypes of diminished daytime alertness and early morning rising among the elderly[1] hint at possible circadian alterations. Studies confirm that **many physiological and behavioral functions that typically display circadian rhythms are altered with advancing age in humans.** For example, there are usually conspicuous changes in sleep habits, such as earlier onset of sleepiness, early morning awakening, and increased daytime napping (93,101). During sleep, there is an increase in the number and duration of waking episodes, there is a reduction in the nondreaming phases of sleep, the first REM phase occurs earlier in the night, and the tendency to fall asleep is increased during the day (18,20,29). Other circadian rhythms, such as body temperature, activity, and the secretion of hormones, including cortisol, are also altered with age (29,93,138,193).

While factors such as changing social habits, medication, and disease processes can impinge on functions that exhibit circadian rhythms, such as sleep, activity, alertness, and hormone secretion, research suggests that aging affects the circadian system itself. A decrease in the amplitude and length of various cycles with age has been observed in animal studies, including longitudinal studies (114, 126,196).[2] Studies of various circadian rhythms in humans have suggested that the length of the circadian cycle shortens with age and that the amplitude of circadian rhythms is blunted (28,105,160,186,193). Furthermore, coordination of various circadian rhythms, such as body temperature, hormone levels, and the sleep-wake cycle, may be lost with age (105,186).

What is the basis for these changes in circadian rhythms with age? It has been suggested that a decreased number of nerve cells in the SCN corre-

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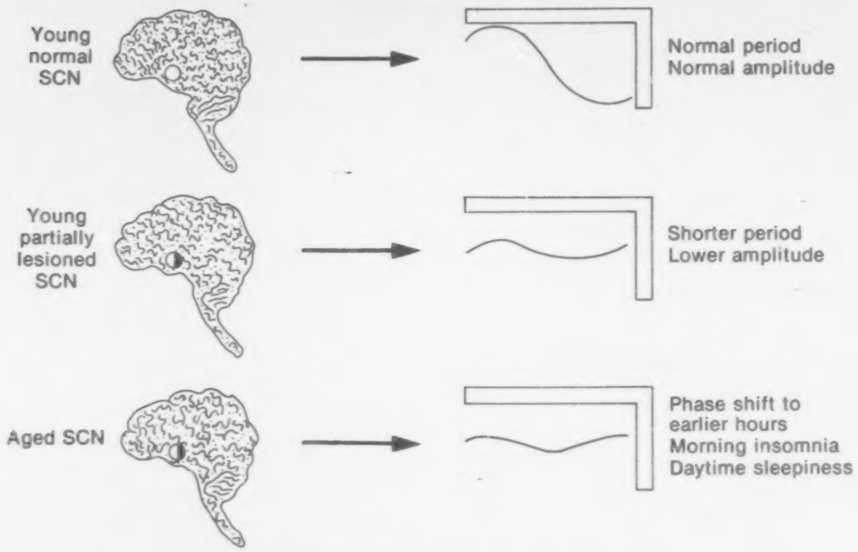
[1] Changes in circadian rhythms associated with aging, as discussed in this section, may refer to different populations of older people. Most research on sleep parameters focused on subjects age 65 or older. Anatomical changes in the brain have been observed in subjects over 80. Difficulties associated with shift work or jet lag have generally been studied in subjects age 45 or older.

[2] Longitudinal studies involve analysis of a particular function in individual subjects over a period of time. They are especially useful for determining effects that exhibit a great deal of variation among individuals, as circadian rhythms do. While longitudinal data concerning circadian rhythms in animals have been collected (114, 126), no similar data are available on humans.

Figure 3-10—Aging and the Pacemaker



The influence of the pacemaker (SCN) on the length and amplitude of circadian rhythms, linking the decreased amplitude in rhythms with disturbed sleep among the elderly.

SOURCE: Adapted from G.S. Richardson and J.B. Martin, "Circadian Rhythms in Neuroendocrinology and Immunology: Influence of Aging," *Progress in NeuroEndocrinImmunology* 1:16-20, 1988.

lates with a decrease in cycle length and perhaps dampened amplitude (figure 3-10) (29,139). Support for this idea is derived from several studies: when some SCN neurons are destroyed in young animals, the length and amplitude of circadian rhythms are diminished, much as they diminish with advancing age (37,123). A decrease in the number or function of SCN neurons has been associated with aging in rats (24,141). Similarly, a decrease in the number of SCN neurons and the overall size of the SCN was documented in humans over the age of 80 (66, 166,167).

Other biological changes with age may impinge on circadian rhythms. For example, relay of synchronizing cues, such as light, may be hampered. There is evidence that some eye problems that occur with age may impede the transmission of light information to the SCN (162). It is possible that changes in the eye may precede and even induce changes in the SCN. Several studies of humans and animals have reported diminished responsiveness to synchronizing cues with age, despite a decrease in the amplitude of circadian rhythms, which normally eases synchronization (29).

While many elderly people fail to report any circadian rhythm-based problems, some studies have illuminated difficulties. For example, adjusting to rotating shift work schedules and transmeridian flight is more difficult among older people (134). In addition, advanced sleep phase syndrome, a disorder in which sleep occurs earlier than usual, appears to be common among the elderly (174). A considerable proportion of older people complain of sleep problems: one study found that 33 percent of older people visiting a general practitioner complain of frequent early morning awakening (97). Lessened performance and alertness during the day may result from fatigue or the lack of synchrony among circadian rhythms. **Thus, changes in circadian rhythms with age may cause a broad spectrum of effects, ranging from no complaints whatsoever, to disturbances of everyday life, to severe health problems.**

Sleep Disorders

Just as the timing of sleep is the most prominent indicator of circadian rhythms in humans, it may also be the cycle most susceptible to disruption (32). **It is now recognized that some types of insomnia most likely result from abnormalities in circadian rhythms.** In the recently revised *International Classification of Sleep Disorders* (2), several sleep disorders are ascribed to problems with circadian rhythms, including:

- advanced sleep phase syndrome,
- delayed sleep phase syndrome, and
- non-24-hour sleep-wake disorder.

Advanced sleep phase syndrome is a common sleep disorder among the elderly, affecting up to one-third of that population (97). It involves early onset and offset of sleep. Research indicates that diminished circadian cycle length and amplitude underlie the disorder (28,193). Advanced sleep phase syndrome may have several consequences, including decreased daytime alertness, overuse of hypnotics and other drugs, and social disruption.

Delayed sleep phase syndrome, or insomnia, is characterized by abnormal delay of sleep onset and waking (2). Persons with this form of insomnia are generally teenagers and young adults. They complain that, on retiring at a bedtime common for most individuals, they are unable to fall asleep. Waking in time for early morning classes or work is also difficult, and they may suffer from fatigue caused by inadequate sleep at night. If individuals with this disorder are permitted to retire and arise at a later hour, although out of step with the environment and society, they can achieve an adequate amount of sleep. It is postulated that the cause of this disorder may be either an abnormally long circadian cycle or a diminished responsiveness to cues in the environment that reset the circadian pacemaker each day (33,119).

Non-24-hour sleep-wake disorder is also likely to reflect disruption of the circadian system. Individuals suffering from this disorder find themselves retiring for and waking from sleep at progressively later times (2). When the timing of sleep onset and awakening coincides with that of the world around them, individuals with this disorder are asymptomatic. When their circadian rhythms are not in synchrony with the environment, individuals with this disorder complain of insomnia, difficulty awakening, and fatigue. One survey showed that 40 percent of blind persons may suffer from non-24-hour sleep-wake disorder (100). These data indicate that the inability to perceive light-dark cycles probably causes the disorder.

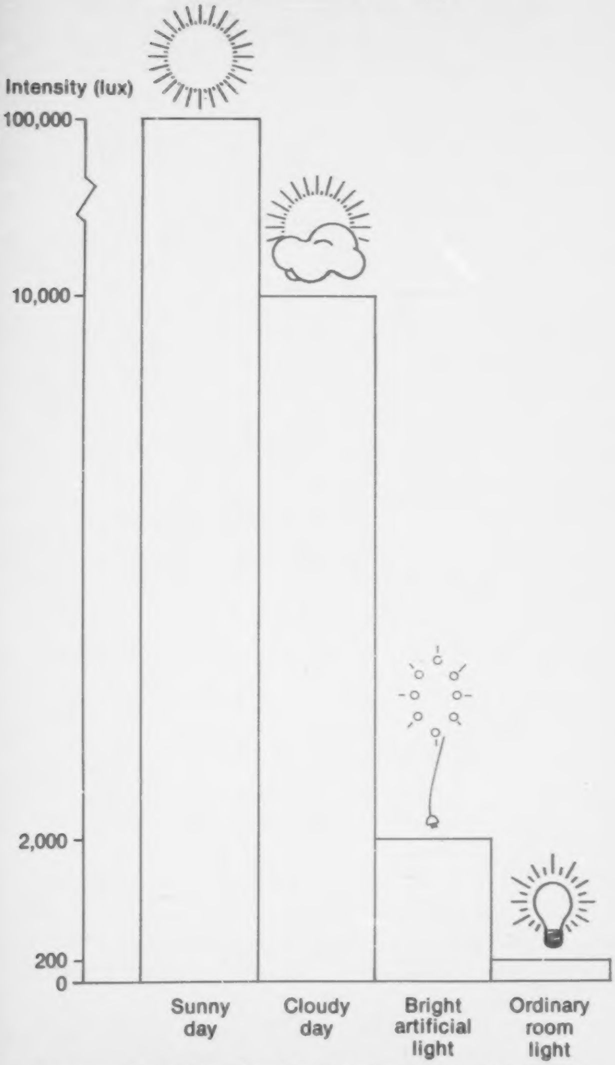
Photo credit: Neal Owens, Sun Box Co., Rockville, MD

A light box used for the treatment of SAD.

Chronobiology and Mood Disorders

While seasonal tendencies in mood disorders have been noted for hundreds of years, the recent surge in research into circadian rhythms has triggered a systematic examination of this phenomenon. Several current hypotheses suggest that an alteration of circadian rhythms leads to various mood disorders. Furthermore, exposure to bright light appears to be an effective therapeutic intervention in some cases. Continued research is necessary, however, to verify the link between circadian rhythm disruption and mood disorders. **In the 1980s, researchers first documented a mood disorder involving a recurring autumn or winter depression (144).** Currently, this form of seasonal affective disorder (SAD) is the subject of extensive study; although the symptoms and diagnostic criteria are somewhat disputed, SAD and its treatment with bright light are generally recognized by the psychiatric community (1,17,58). Each fall or winter, individuals suffering from SAD may tire easily, crave carbohydrates, gain weight, experience increased anxiety or sadness, and exhibit a marked decrease in energy (144,146). With protracted daylight in the spring, patients emerge from their depression and sometimes even display

Figure 3-11—Levels of Light



The comparative intensity of light. Bright artificial light is effective for shifting human circadian rhythms.

SOURCE: A. Lewy, Oregon Health Sciences University, 1991.

modest manic symptoms. Epidemiological studies indicate that SAD is related to latitude, with the number of cases increasing with distance from the equator (127,143).

Although there is no agreement about how light therapy works, data from several studies suggest that it is a useful treatment for SAD (144,170). The recommended protocol for treatment involves exposure to light with an intensity of 2,500 lux (which is equivalent in intensity to outdoor light at dawn) for 2 to 5 hours per day (figure 3-11). Some researchers have asserted that shorter periods of exposure to very bright light (e.g., 10,000 lux for 30 minutes) may also relieve symptoms (170,172). Data from several studies suggest that morning exposure to light is most effective in relieving symptoms of SAD, although this issue is unresolved (17,89,170,172).

The cause of SAD and the way in which light therapy alleviates it are not known. It has been hypothesized that circadian rhythms are delayed or possibly that the amplitude is dampened (17,86,89). To date, however, **SAD has not been proven to be a circadian rhythm disorder**. Problems that plague this area of research include heterogenous populations of study subjects, small sample sizes, lack of adequate controls, lack of longitudinal studies, and the absence of controls for the effects of sleep, activity, and light on circadian rhythms (17,172). Further studies are necessary to delineate the basis of SAD.

Nonseasonal depression is a significant cause of mental illness in the United States, affecting nearly 1 in 12 Americans. Although not proven, **several observations suggest a link between altered circadian rhythms and nonseasonal depression** (17,32). Among persons suffering from depression, mood typically fluctuates daily, with improvement over the course of the day. Persons also demonstrate seasonal patterns, with an apparent increase in the incidence of depression, as indicated by hospital admissions, electroconvulsive therapy, and suicide records, in the spring and autumn. Various physiological functions may exhibit an altered circadian pattern in depression, notably the timing of REM sleep. In people suffering from depression, the first REM episode occurs earlier after sleep begins, and REM sleep is abnormally frequent during the early hours of sleep (80). Rhythms of body temperature, hormone and brain chemical secretion, and sleep-wake cycles deviate during episodes of depression, peaking earlier than is the norm or, more commonly, exhibiting dampened amplitude.

The action of various antidepressant drugs and therapies provides further evidence for a link between circadian rhythm disruption and depression (49,58). Some animal studies have shown that several classes of antidepressant drugs either lengthen the circadian cycle, delay distinct circadian rhythms, or influence synchronization with environmental cues. Studies showing that late-night sleep deprivation temporarily alleviates depression also suggest, but do not prove, a link between circadian rhythms and nonseasonal depression. Assessment of 61 studies, with more than 1,700 patients, indicated that missing one night's sleep halted depression immediately in 59 percent of the patients (the next sleep episode usually resulted in the return of depression, and in more than a quarter of the patients a manic episode was triggered) (198).

While this information suggests a potential causative relationship between circadian rhythm disruption and depression, **little direct evidence supports the hypothesis that nonseasonal depression is a circadian disorder**. For example, only a few studies have indicated a phase advance or blunted circadian amplitude. Most studies share similar problems as those described above for SAD, including heterogeneous samples, small sample sizes, and failure to evaluate circadian rhythms isolated from the influence of the environment.

CONTROLLING CIRCADIAN RHYTHMS IN HUMANS

Interest in manipulating the internal clock has grown with improved understanding of human circadian rhythms and increasing awareness of circadian rhythm disruption, whether precipitated by intrinsic factors (e.g., sleep disorders, blindness, mental disorders, or aging) or extrinsic factors (e.g., air travel across time zones and shift work) (box 3-D). Several agents are under investigation or have been proposed for use in manipulating circadian rhythms. In order to assert that an agent's primary action is on the circadian system, several questions must be addressed, including: How are circadian rhythms modified? Are all circadian rhythms altered or only certain rhythms, such as the sleep-wake cycle? How is the circadian pacemaker influenced? Does the effect vary at different times during the circadian cycle (i.e., has PRC been evaluated)? Does the agent have any side effects or drawbacks? Several agents show promise for manipulating human circadian rhythms, including:

- light,
- melatonin,
- benzodiazepines,
- other chemical substances and diet, and
- activity.

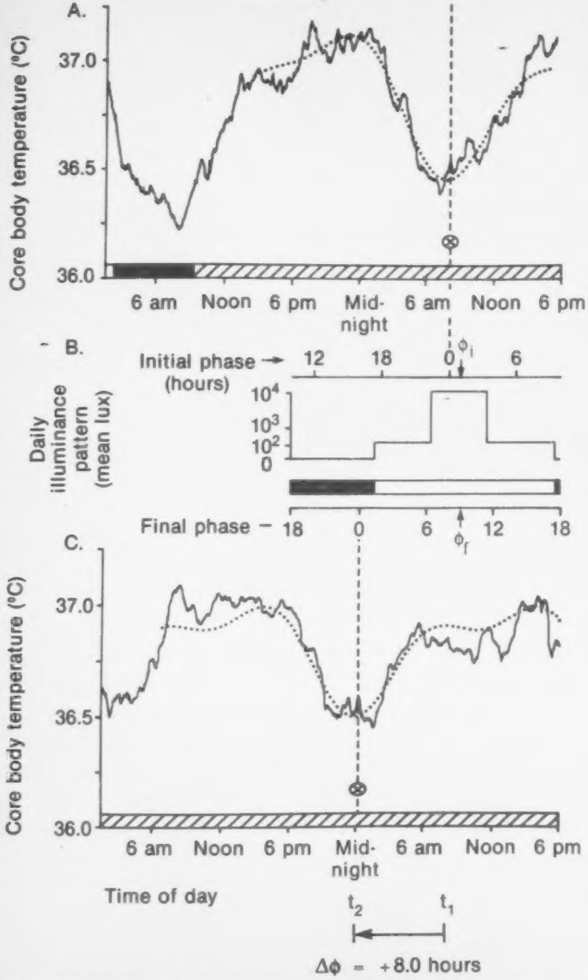
Light

Light-dark cycles are the single most important environmental cue for synchronizing the internal clock to the Earth's 24-hour cycle. As mentioned, light's ability to reset the internal clock was first discovered by exposing organisms to pulses of light at different times throughout the circadian period (40,65,125). In these experiments, exposure to light at night produced the largest shifts in rhythms, with late-night pulses advancing rhythms and pulses during the early part of the night delaying them. Other studies have shown that the phase-shifting effects of cycles of light and dark are similar to those of light pulses.

The synchronizing effect of light on human circadian rhythms has only been recognized in the last 10 years (33). Previously, social contacts were thought to synchronize human circadian rhythms, since light-dark cycles apparently failed. This conclusion was questionable, for several reasons. First, subjects were permitted to use lamps at will in the original study and therefore were never completely limited to an imposed light-dark cycle. Also, the design of the studies prevented discrimination between the effects of social contact and those of rest, activity, or eating. A subsequent study reported synchronization of human circadian rhythms when an absolute light-dark cycle was imposed, but the experiment did not differentiate between the effects of the light-dark cycle and the timing of sleep on circadian rhythms, since subjects always retired to bed at the time lights were turned out.

The discovery that bright light (2,500 lux) suppresses the production of the human hormone melatonin (92) triggered a reassessment of light's effects on human circadian rhythms. In one study, light-dark cycles were shown to significantly synchronize human circadian rhythms (195). Subsequent studies illustrated the phase-shifting effects of light on humans. For example, in one study, exposure to 4 hours of very bright light (7,000 to 12,000 lux) was shown to delay circadian rhythms in a single subject whose rhythms were unusually advanced (figure 3-12) (28). These and other studies support the hypothesis that bright light shifts human circadian rhythms, the size and direction of the shift depending on when in the cycle exposure takes place (38,39,43,44,47,67,90,91,103, 195).

Figure 3-12—Resetting the Human Pacemaker With Light



The first graph (A) illustrates the original circadian rhythm of body temperature. Following exposure to bright light, as illustrated in B, the rhythm of body temperature was significantly shifted (C).

SOURCE: C.A. Czeisler, R.E. Kronauer, J.S. Allan, et al., "Bright Light Induction of Strong (Type 0) Resetting of the Human Circadian Pacemaker," *Science* 244:1328-1332, 1989.

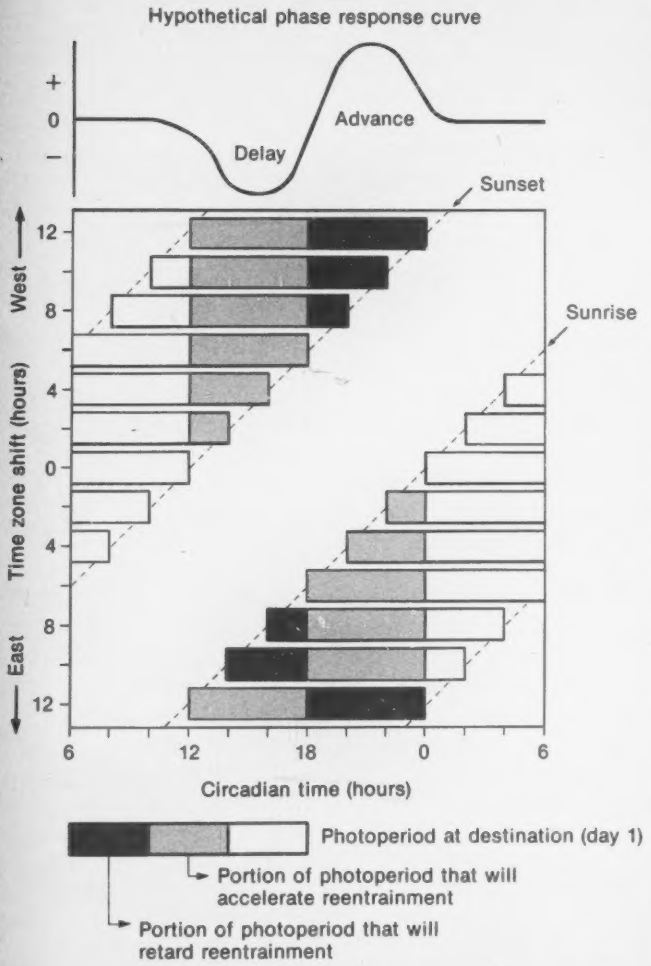
More recent studies report a human PRC to light (31,194). For example, one study exposed human subjects to varying cycles of very bright light (7,000 to 12,000 lux), ordinary room light, and darkness (31). The greatest shift in circadian rhythms (several different rhythms were measured) was produced when the exposure to very bright light occurred approximately 3 hours before the usual waking time; exposure immediately preceding or following this time maximally delayed or advanced rhythms, respectively. This study also suggested that low-intensity light (150 lux) modifies the phase-shifting effects of very bright light, a pattern that resembles the effect of light on circadian rhythms in other organisms. Recent experiments have provided further evidence of the similarity of light's effects on human and other species' circadian rhythms (72).

The methods used in these human studies to evaluate and manipulate circadian rhythms differ from the methods used in animal studies, leaving room for speculation concerning the mechanism by which light produces its effects. The influence of sleep, fatigue, or darkness in these studies is not known, nor is the mechanism by which light influences human circadian rhythms well defined. However, accumulating evidence shows that, as in other animal species, light, especially bright light, is effective in shifting human circadian rhythms. The phase-shifting properties of bright light have been applied in several situations:

- Exposure to bright light is now used in certain clinical centers and research settings to treat some sleep disorders and elderly persons suffering from circadian rhythm disruption.
- A published research plan for exposure to sunlight has been proposed to speed recovery from jet lag (figure 3-13) (36).
- Recent studies have evaluated the influence of bright light and darkness cycles on the circadian rhythms, sleep, and performance of workers at night (see ch. 5) (30).
- Although the basis for SAD has not been definitely linked to circadian rhythm disruption, bright light therapy appears to be beneficial for patients (145,170).

The potential adverse effects of using light to reset circadian rhythms (as well as in the treatment of SAD) have not been systematically studied. Since it is a nonpharmacological intervention, it probably presents fewer detrimental effects. It has been argued that since the intensity of light used to modulate human rhythms is far less than the intensity of outdoor daylight, there is little risk involved. However, experience with SAD has led to some concern that artificial bright light may present a risk of damage to the eye (171). To date, studies evaluating the health of the eye following bright light therapy for SAD have failed to document any damage, although the risk of long-term effects has not been ruled out. Also, it is not clear what harmful consequences, if any, would result from repeated

Figure 3-13—Bright Light and Air Travel



Exposure to bright light following travel across time zones may influence circadian rhythms. For example, after flying 2 hours from the west to the east, it is suggested that bright light exposure begin at dawn for 2 hours.

SOURCE: S. Daan, and A.J. Lewy, "Scheduled Exposure to Daylight: A Potential Strategy To Reduce Jet Lag Following Transmeridian Flight," *Psychopharmacology Bulletin* 20:566-568, 1984.

resetting of the circadian pacemaker, such as when using bright light to help shift workers adjust to their changing work schedules.

Exposure to ultraviolet (UV) radiation is another potential concern raised by the use of bright lights. In research and clinical settings (for the treatment of SAD), fluorescent lighting, both that emitting UV radiation and that designed to limit it, has been used. One study reported that exposure to UV light was within established safety guidelines following several hours of exposure to wide-spectrum fluorescent light of 7,000 to 12,000 lux (30). Evidence shows that UV radiation is not necessary for adjusting rhythms, although it may have some effect on them. Bright light may also produce unpleasant but transient side effects of irritability, eyestrain, headaches, or insomnia.

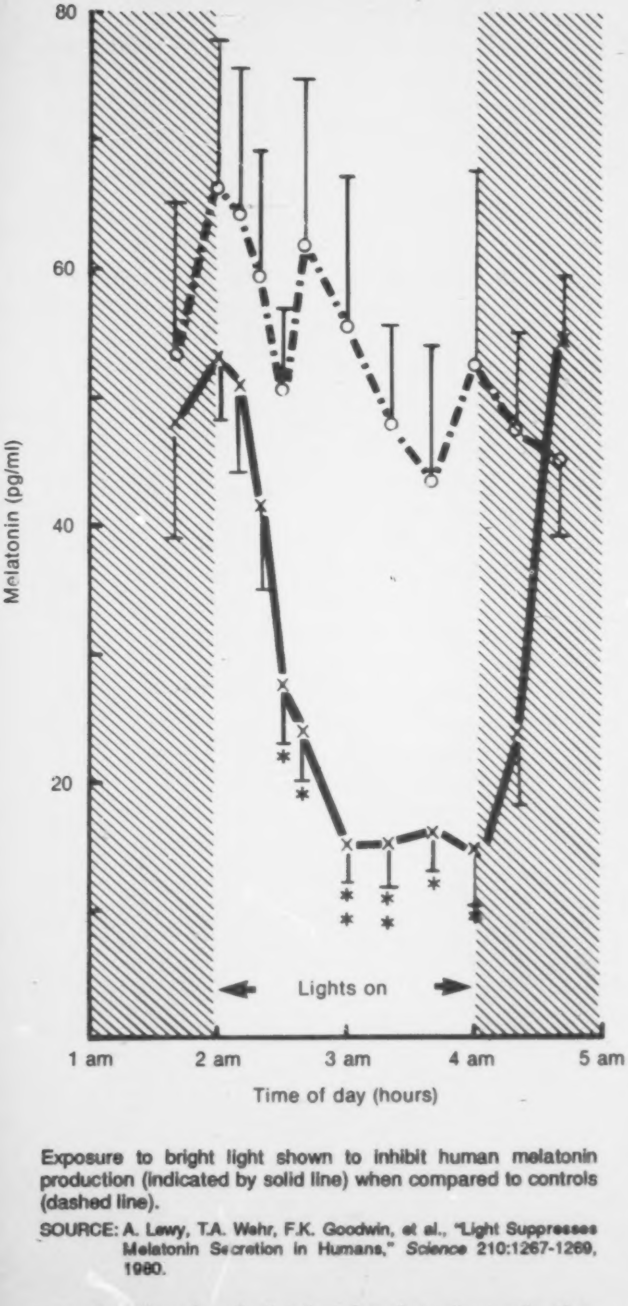
Melatonin

The hormone melatonin is produced by the pineal gland, a small, pealike structure that in humans sits deep within the brain. In lower vertebrates, the pineal gland is positioned near the top of the skull and detects light directly, thus its designation as the third eye (3). In mammals, including humans, information about light in the environment is transmitted from the eye through multiple nerve cells to the pineal gland (74,200). Melatonin secretion is normally limited to nighttime hours, a pattern of secretion that is regulated in two ways: 1) light suppresses the pineal gland's production of melatonin, and 2) melatonin secretion is regulated by the circadian pacemaker, exhibiting a circadian rhythm even in the absence of environmental cues (figure 3-14) (94,95). For this reason, melatonin can be used as a marker for circadian rhythms (90,91); however, its usefulness may be limited because it is so readily inhibited by light.

In many species, melatonin is a gauge of day length, or photoperiod. Seasonal changes in day length alter the amount and duration of melatonin secretion, thereby regulating the timing of fertility, birth of offspring, and other functions. Although responsiveness to day length generally has not been considered a prominent human feature, several human functions, including the onset of puberty, semen production, and some forms of depression (see earlier discussion), display seasonal patterns.

The pineal gland's nighttime secretion of melatonin is postulated to be important for circadian rhythms in many species (178). In some species, including some birds, the pineal gland serves as the circadian pacemaker (99,203). In other species, the pineal gland does not serve as the primary pacemaker, but its removal disrupts circadian rhythms (8,156). Studies have shown that daily melatonin injection can synchronize circadian rhythms in rats, apparently by a direct effect on the pacemaker in the brain (7,21-23,133,137). These and other data sug-

Figure 3-14—Melatonin Rhythms and Light



Exposure to bright light shown to inhibit human melatonin production (indicated by solid line) when compared to controls (dashed line).

SOURCE: A. Lewy, T.A. Wehr, F.K. Goodwin, et al., "Light Suppresses Melatonin Secretion in Humans," *Science* 210:1267-1269, 1980.

gest that the pineal gland and melatonin production may synchronize various circadian rhythms in at least some mammals.

The effect of melatonin on circadian rhythms has also been examined in humans. In some early studies, melatonin both succeeded and failed to act as a synchronizing agent. Other studies reported that melatonin counteracted subjective feelings of jet lag (4,8,121) (see box 3-D), although how it did so was not clear. Some data indicated that melatonin directly influenced circadian rhythms (4,8); however, others failed to confirm this effect (6). Furthermore, the effects of melatonin on jet lag varied considerably among individuals (4). It was suggested that melatonin counters jet lag by facilitating sleep, since it has sedative properties.

A few studies have used blind persons, who are often not synchronized with the environment, to assess melatonin's effect on the circadian pacemaker. In one such study, it was reported that administration of melatonin synchronized the disturbed sleep-wake cycle of a blind individual (5). In another study, a phase advance was produced by daily administration of melatonin in four of five blind subjects with free-running rhythms (151,152). More recently, orally administered melatonin synchronized circadian rhythms in a blind subject (153). Also, melatonin has been reported to cause circadian phase shifts, the direction and magnitude of which appear to vary with the timing of its administration, in sighted individuals (87,88). While another study failed to demonstrate administered melatonin's ability to synchronize or shift circadian rhythms (55), this failure may be due to the timing of melatonin administration. **Further study is necessary to delineate melatonin's action on human circadian rhythms.**

Benzodiazepines

Several studies in rodents have shown that treatment with benzodiazepines, a class of hypnotic drugs which includes Valium, can alter circadian rhythms (130,179). The phase-shifting effects of the short-acting benzodiazepine triazolam (trade name Halcion) have been most extensively studied in the golden hamster. In most of these studies, the timing of locomotor activity (i.e., wheel-running) has been used as a measure of circadian rhythms, although hormonal secretions have also been used. Injection of triazolam produced pronounced phase shifts in wheel-running, the particular effect depending on the dose and timing of administration (177). Triazolam's ability to shift wheel-running was attenuated after a few days of repeated administration, indicating a growing tolerance to the drug.

Besides its ability to cause phase shifts in circadian rhythms, triazolam was also shown to synchronize circadian rhythms when regularly administered. Furthermore, when hamsters experienced a shift in the timing of the light-dark cycle, administration of triazolam at the appropriate time expedited their readjustment (187).

Some data suggest that triazolam's influence on circadian rhythms in hamsters is predicated on its ability to induce locomotor activity (116). Triazolam treatment of hamsters increases activity (176). When locomotor activity is suppressed in hamsters, triazolam no longer produces phase shifts (188). However, stimulation of activity may not be necessary for triazolam's circadian effects in all species.

Is triazolam, or other benzodiazepines, likely to emerge as a jet lag pill, capable of shifting human circadian rhythms? Preliminary studies in humans have suggested that it may facilitate shifts in circadian rhythms, or at least promote sleep when circadian rhythms are in conflict with the environment (184). In addition, the activity and safety of this class of drugs have been well characterized in humans, since benzodiazepines are commonly used to manage insomnia and anxiety. However, while benzodiazepines are useful pharmaceutical agents, they do carry the risk of serious side effects, including memory problems and agitation. They can also exacerbate depression. Long-term use of this type of drug can lead to dependency; therefore, repeated use of benzodiazepines for circadian rhythm adjustment is not tenable. Furthermore, **any effects of benzodiazepines on circadian rhythms in humans have yet to be thoroughly evaluated.** As is the case for their effect on activity, the effects of benzodiazepines on circadian rhythms in humans may be very different from their effects on hamsters.

Other Chemical Substances and Diet

Researchers have speculated that several other chemicals may manipulate circadian rhythms in mammals, including carbachol, phenobarbitol, theophylline, and lithium (11,148,175,191,197). Many of these agents affect specific chemical systems in the brain that are important for nerve cell communication and impinge on the circadian pacemaker. Other agents are characterized by generalized stimulatory or sedative properties (157,164). **There are no data, however, indicating that these substances influence human circadian rhythms.** Furthermore, powerful unwanted side effects cast doubt on the usefulness of many of these substances in counteracting jet lag or shift work.

A popularized diet has been said to manipulate circadian rhythms and has been promoted as an antidote for jet lag (51,199). These claims are based on hypothetical effects of the diet on chemical systems in the brain. Specifically, it has been asserted that morning meals rich in proteins boost concentrations of catecholamines in the brain and consequently stimulate activity. Evening meals rich in carbohydrates purportedly increase concentrations of serotonin, a sleep-inducing chemical in the brain. While a few animal studies suggest that diet can modulate these brain chemicals (82), the protocol used in these experiments does not relate directly to the recommendations for humans. **This dietary protocol has not been shown to influence circadian rhythms in humans.**

Activity

That the timing of arousal and physical activity is intimately linked to the time of day and circadian rhythms appears self-evident; a few studies suggest that physical activity or arousal can synchronize the internal clock (176). The apparent link between triazolam's stimulation of activity and its circadian effects on hamsters has renewed interest in this 30-year-old proposal (9,176). In fact, many agents purported to alter circadian rhythms also alter the amount of activity in animals.

Experiments in rodents demonstrated that simply having access to a running wheel changes the length of the circadian cycle (13,201). A few other studies indicated that when specific periods of physical activity or other forms of arousal are provided, a phase shift in the circadian cycle can be produced (116,128,176). One study reported phase response to "doses" of activity: variable phase shifts resulted from periods of arousal or social activity at different times during the 24-hour period (115).

Although these studies suggest that activity modulates circadian rhythms in animals, further experimentation is necessary to characterize this effect. Since the state of being active or aroused is so general, there is some question as to what specific features of this state affect circadian rhythms. Finally, the impact of activity and arousal on circadian rhythms has yet to be carefully evaluated in humans.

SUMMARY AND CONCLUSIONS

Research has indisputably demonstrated that living organisms, ranging from single cells to humans, are able to keep track of time and to direct changes in function accordingly. Such functional cycles that repeat approximately every 24 hours are called circadian rhythms. Circadian rhythms are generated by living organisms and are genetically determined. Environmental cues synchronize circadian rhythms in organisms, the most important cue being light-dark cycles. In mammals, including humans, a region of the brain called the suprachiasmatic nucleus serves as the circadian pacemaker.

Most organs in the human body display circadian rhythms. Especially significant for shift work are sleep-wakefulness and performance rhythms. Daily cycles of sleep and wakefulness are a conspicuous circadian rhythm in humans. Studies have shown that the circadian pacemaker significantly influences the timing and quality of sleep. Therefore, periods of sleep are not easily rescheduled, deferred, or resisted. Human performance, assessed by measures of reaction time, cognitive processes, and mood, also displays circadian rhythms, which vary according to the nature of the task or mood assayed. Factors such as fatigue and motivation also profoundly influence human performance. When individuals are synchronized to the natural day-night cycle, many performance rhythms diminish to minimal levels at night. This nighttime attentuation of performance reflects the combined effects of circadian rhythms and the lack of sleep.

Research during the last few decades has demonstrated that humans have an internal clock and suggests that violation of its temporal order may exact a price in health and performance. When internally generated circadian rhythms conflict with environmental cycles, which happens following transmeridian flight and in some schedules of shift work, performance may be impaired, sleep disordered, and a general malaise experienced. Data indicate that the generation of circadian rhythms is altered with aging and in certain sleep disorders. Circadian rhythms may also be altered in certain mental disorders.

Several agents, including light, melatonin, benzodiazepines, other chemical substances, diet, and activity, are under investigation for their ability to adjust or shift circadian rhythms. Data indicate that bright light, the most extensively studied agent, can shift human circadian rhythms. How it does so, however, is not completely understood. Further research is necessary to substantiate the circadian effects of the other agents in humans.

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Chapter 4

The Prevalence and Use of Shift Work

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Chapter 4

The Prevalence and Use of Shift Work

Some 20 million Americans—approximately one in five employed persons—can be broadly defined as shift workers, that is, they do not work a standard daytime schedule (15). Instead, they work evenings, nights, a split or extended shift, or rotating shifts. These shift schedules, some of which conflict with biological rhythms and social time order, are used in many occupations and industries, ranging from the health care professions to the manufacturing and transportation industries to clerical positions. Various factors, including demand for services, the amount of time required to perform a procedure or task, technological advances, and expense, have led to the spread of shift work. Clearly, shift work is required in any modern, industrially developed country.

This chapter discusses and evaluates the prevalence of shift work in the United States. It describes national sources of data on shift work, the prevalence of shift work and its use in different employment sectors, and the demographic characteristics of shift workers. A final section outlines available data on specific work schedules. Although economic and technological factors significantly influence the use of shift work and specific schedules, they are beyond the scope of this chapter.

THE DEMOGRAPHICS OF SHIFT WORK

A basic demographic issue in any consideration of shift work is its overall prevalence. Since estimates of shift work vary with the definition used, it is important to consider how shift work is measured in national surveys. Who is a shift worker? In general, a shift worker is defined as someone who does not regularly work a standard daytime schedule. But what is standard? Not only is this an arbitrary determination, so is the definition of an evening, night, or split shift and of what constitutes shift rotation. There is considerable variation in the work hours of nonstandard schedules, depending on the nature and place of employment.

Defining a Shift Worker

National demographic surveys generally ask about shift work in one of two ways:

- by having respondents classify their shift, with minimal, if any, instruction provided; and
- by asking respondents about the specific hours they work (each day or most days of the week) and then determining their shift status according to precise guidelines.

Each approach has limitations.

Self-classification provides responses that are difficult to interpret. For example, some respondents may call themselves "day workers" when they work between 1 p.m. and 9 p.m.; others with the same hours of employment may regard themselves as "evening workers." The advantage of self-classification is that it requires only one question on the questionnaire, minimizing respondent time and cost.

In contrast, a series of questions is required to obtain people's actual work hours. This series might include some or all of the following: the time work begins, the time work ends, and whether the shift rotates. These questions may be asked with regard to most days during a reference week prior to the survey or for all days of the week. Although more time-consuming and costly, this procedure allows for precise definition of shifts. These definitions, although explicit, vary by researcher, depending in part on whether the investigator is considering starting time only or both starting and ending time, and whether shift rotation is taken into account. For example, a person who works during the day within the reference period of the survey may actually work a rotating shift, but this will not be clear unless a question about shift rotation is asked.

Sources of National Data on Shift Work

The most comprehensive data on the prevalence of shift work in the United States are based on supplements to the Current Population Survey (CPS) (table 4-1). The CPS is a household sample survey conducted monthly by the Bureau of the Census (within the U.S. Department of Commerce) for the Bureau of Labor Statistics (BLS)

Table 4-1—Sources of National Data on Shift Work

Survey	Conducted by	Years administered	Size
Current Population Survey (CPS) May supplement	Bureau of Labor Statistics	1972 to 1980; 1985,1991	55,000 to 60,000 households
June supplement	Bureau of Labor Statistics[a]	1982	55,000 to 60,000 households
Quality of Employment Survey	Institute for Social Research, University of Michigan	1977	1,515 persons
National Survey of Families and Households	Center for Demography and Ecology, University of Wisconsin	1987 to 1988	13,017 persons and spouses or cohabitants
National Longitudinal Survey, Youth Cohort	Center for Human Resource Research, Ohio State University	1979 to present	12,686 persons and spouses

[a] Sponsored by the National Institute of Child Health and Human Development.

SOURCE: Office of Technology Assessment, 1991.

(within the U.S. Department of Labor). A portion of the labor force in the United States is regularly asked a fixed list of questions regarding employment. The number of households surveyed each month generally ranges from about 55,000 to 60,000. Data are collected for all members of the household age 16 and over, and beginning in 1980 some basic demographic questions on children in the household were also asked. In May of each year between 1973 and 1980, a supplement was added to the CPS with questions on the specific hours of employment (beginning and ending time) for the principal job held the previous week and questions on whether more than one job was held (but none on the hours employed in nonprincipal jobs). In May 1980, data were collected for the first time on whether or not the principal job was a rotating shift. All questions on specific work hours were asked only of wage and salary earners (self-employed persons were excluded).

Between 1980 and 1985 there were no supplements to the May CPS on work schedules. However, in May 1985 there was a supplement which went beyond the earlier ones to include questions on which days and hours people worked and, for persons with more than one job, the hours work began and ended on the second job. Whereas the work hours continued to be asked with regard to the reference week, shift rotation was defined differently in 1985, affecting the precision with which one can compare the 1985 results with those from earlier years. In May 1985, employed persons were also asked to categorize their usual work shift; interviewers were given rough guidelines to help if there was difficulty.[1] Unlike the previous May CPS supplements, in 1985 the shift work questions were asked of all employed persons. **A supplement with shift work questions was added to the May 1991 CPS, which will provide the most recent estimates of national shift work prevalence since 1985.**[2]

In addition to the May CPS supplements, the June 1982 CPS supplement contained some data on shift work. This supplement (sponsored by the National Institute of Child Health and Human Development) focused on fertility and child care and included questions on the time work began and ended (but not shift rotation) for employed women with children under the age of 5. The supplement provided the first opportunity to consider at a national level shift work in relation to child care use, although it is limited to women with pre-school age children.

Until recently, the only other national data on shift work were from the 1977 Quality of Employment Survey (QES). This survey was a national probability sample[3] of 1,515 persons age 16 and over who were working for pay for 20 or more hours per week. Although the survey was conducted in earlier years, only in 1977 were questions asked on the specific working hours of respondents and their employed spouses, if married. Moreover, because of the sample design and the definition of shift work, the data are problematic in assessing the prevalence of shift work in the United States in 1977.[4]

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[1] The CPS obtains information on all household members from one adult member. Accordingly, the work schedules of all employed persons are reported by one person and thus are more subject to error than if truly self-reported.

[2] Appropriations for the BLS have been reduced by nearly $14.5 million over the last 3 years, undoubtedly limiting data collection (9).

[3] A national probability sample is selected on the basis of statistical procedures that, with appropriate weighting, yield a sample that represents the total U.S. population and can be generalized accordingly.

A recent and comprehensive source of data on shift work at the national level is the 1987-88 National Survey of Families and Households, conducted by the Center for Demography and Ecology at the University of Wisconsin. This survey is a national probability sample of 13,017 respondents and, for those married or cohabiting, their spouses and partners. It asks the most detailed questions about work schedules of any national survey to date, including the hours work began and ended for each day of the week and shift rotation. It also includes detailed data on family attitudes and behavior. Although no analyses of the effects of shift work have been completed using these data, preliminary results on prevalence are consistent with the 1985 May CPS findings (17).

Although specific to a particular age group, another key source of data for the study of shift work in the United States is the National Longitudinal Survey, Youth Cohort, conducted for the BLS by the Center for Human Resource Research at Ohio State University. This survey is a national probability sample of 12,686 persons age 14 to 21 as of January 1, 1979, the year of the first interview, with annual interviews thereafter. A self-defined shift status was asked of employed persons almost every year of the study. Beginning in 1983, employed persons with children were also asked the specific hours their work began and ended, as well as the work hours of employed spouses, if married. Questions about shift rotation were asked in some years but not others. In 1988 through 1990, specific hours worked and shift rotation questions were asked of all employed persons, not just those with children, and all employed spouses, if married. These data, however, have not yet been analyzed.

The above sources are all based on household surveys, and information is collected from one or more household members. The BLS has collected data on shift work and scheduled weekly hours from employers, in the Area and Industry Wage Surveys, for various years since the end of World War II. Although the findings of these surveys are reported only for specific industries and selected metropolitan areas, they are important because they provide data on pay differentials by shift status.

Estimates of Shift Work Prevalence

The most widely used estimates of the prevalence of shift work in the United States are from the May CPS supplements, starting with 1973. Between 1973 and 1980, BLS published tabulations of full-time nonfarm workers (employed 35 or more hours per week), and the determination of the work schedule was based on beginning and ending times of shifts. A day shift was defined as half or more hours of employment between 8 a.m. and 4 p.m., an evening shift as most hours between 4 p.m. and midnight, a night shift as most hours between midnight and 8 a.m., and a miscellaneous shift as fewer than 6 or more than 12 hours a day (including split shifts).

Based on these criteria, the prevalence of shift work changed little between 1973 and 1980, at least for full-time nonagricultural workers (data on part-time workers are not available): about one out of six full-time workers was employed in shift work (24). This proportion, however, is an underestimate, since persons on rotating shifts were not identified prior to 1980. Accordingly, everyone on a rotating shift who worked a day schedule in the reference week of the survey was classified as a day rather than a nonday worker. Adjusting for this misclassification in the 1980 data, it has been estimated (11) that **one out of five full-time nonagricultural wage and salary workers in the United States was a shift worker.** Again, these figures relate to the principal job only (6.2 percent of the employed population in 1989 held multiple jobs) (19).

The 1985 CPS data on work shifts are not strictly comparable to those for 1973 to 1980 because of definitional differences, as noted above. Crude comparisons suggest little change in the overall prevalence of shift work between 1980 and 1985. From tabulations of the May 1985 CPS, it can be estimated that one in five nonagricultural workers (both wage and salary workers and the self-employed, part-time and full-time combined) was

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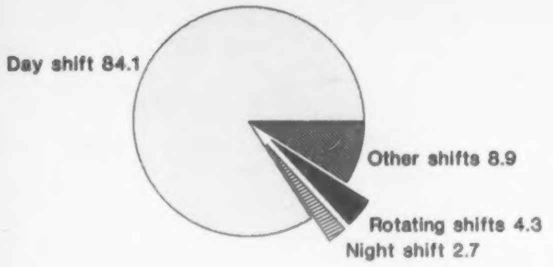
[4] Both part-time and full-time workers were grouped together, with no minimum hours required for the employment of spouses of respondents but a 20-hour minimum for respondents themselves. Shift workers were defined as persons who did not begin work between 3:30 a.m. and 11:59 a.m. and thus include spouses who work a few hours in the afternoon.

Figure 4-1—Percentage of Shift Workers Among Full-Time Employees in the United States



SOURCE: E.F. Mellor, "Shift Work and Flexitime: How Prevalent Are They?" *Monthly Labor Review* 109: 14-21, 1986.

employed in shift work (figure 4-1).[5] This estimate is based on specific work hours (as in earlier years), but it closely approximates figures based on the respondent's categorization of his or her shift status and is limited to wage and salary workers only, part-time and full-time combined (8).[6] According to the BLS figures, persons working part-time (fewer than 35 hours per week) were much more likely to be working a shift (47.5 percent) than those working full-time (15.9 percent) (8).

In the 1985 CPS supplement, 2.7 percent of full-time workers and 5.0 percent of part-time workers were classified as night workers. Therefore, approximately 2.0 million individuals work at night. Another 4.3 percent of full-time workers, approximately 3.1 million people in the population, reported working rotating shifts. While some, if not most, of these individuals occasionally work at night, the survey does not differentiate rotation schedules that include night work from those that do not.

Shift Workers in Various Employment Sectors

Many occupations and industries involve shift work. The factors that lead to shift work, however, vary considerably. Specific reasons for adopting shift work schedules include:

- an extended period of time required to complete a particular job or process,
- a constant need or extended demand for services,
- economic factors (e.g., the expense of capital investment, the need for maximum competitiveness), and
- technological advances.

In the following section, the prevalence of shift work in various employment sectors is discussed (table 4-2).

In manufacturing, the use of shift work and night operations may reflect several considerations. A high ratio of capital investment to labor costs is an important incentive for maximizing the use of plants and equipment and therefore operating at night (5). Continuous-process industries, like basic steel, may operate around the clock to avoid high startup and shutdown costs. Some industries are characterized by processes that require extended periods of time (more than 12 hours) for completion. This is the case for many chemical manufacturing processes. Other factors, such as increased demand for a product and favorable utility rates at night, also favor the establishment of 24-hour operations.

The importance of capital investment for the prevalence of shift work and night operations is borne out by data collected by the BLS from industries in large metropolitan areas (5). For the period 1979 to 1984, capital-intensive industries and continuous-process operations had as many as 50 percent of employees working evening or night shifts.[7] In contrast, less than 3 percent of workers in labor-intensive industries are scheduled for an evening or night shift.

Shift work is prevalent in transportation occupations and industries, including trucking, airlines, railroads, and shipping (table 4-2).[8] Among those employed by public utilities and transportation industries, 20.6 percent are shift workers. Of full-time motor vehicle operators, 25.5 percent are shift workers, approximately half of them working night or rotating shifts (8). While many transportation sectors are governed by hours of service regulations, these regulations do not preclude night work, shifts

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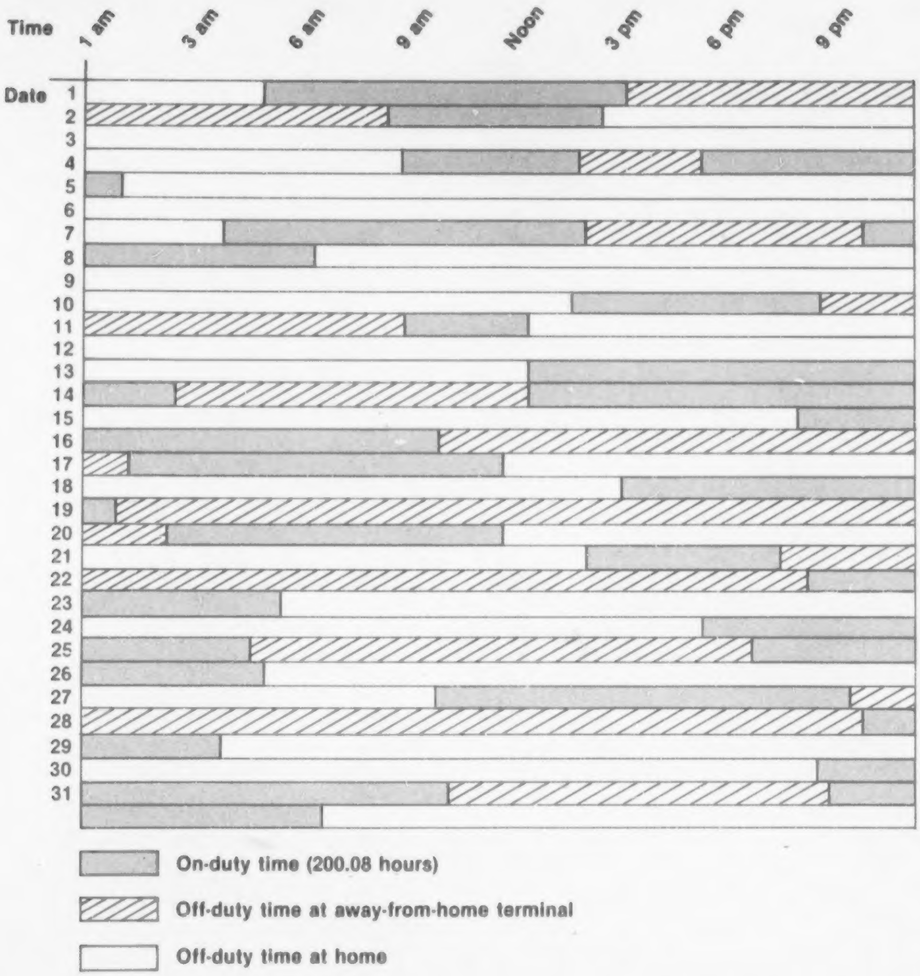
[5] Table 4-2 lists a lower estimate than one in five, based on self-definition rather than actual hours, and is limited to full-time workers only.

[6] All published tabulations on shift work by the BLS for 1985 are based on self-categorization and are limited to wage and salary workers.

[7] These surveys have been repeated since 1984.

[8] Shift schedules and hours of service regulations for the transportation industry are discussed in detail in ch. 6.

Figure 4-2—A Month in the Life of a Locomotive Engineer



Actual work history of a locomotive engineer on a pool freight run of 182 miles, from October 1 to 31, 1990.

SOURCE: C.E. Anderson, Brotherhood of Locomotive Engineers, 1991.

exceeding 8 hours, or erratic scheduling (figures 4-2 and 4-3).

Around-the-clock operations are also demanded by various service industries, which are a significant and growing sector of the U.S. economy. Certain services may be in demand during nonstandard hours because of the nature of the service itself or the needs of customers employed during standard hours. For example, continuous service is required from police and firefighters, hospital staff, nightguards, and military personnel. Persons employed in the retail and entertainment industries are also involved in shift work.

The 1985 CPS data illustrate the disproportionately high percentage of shift workers in service

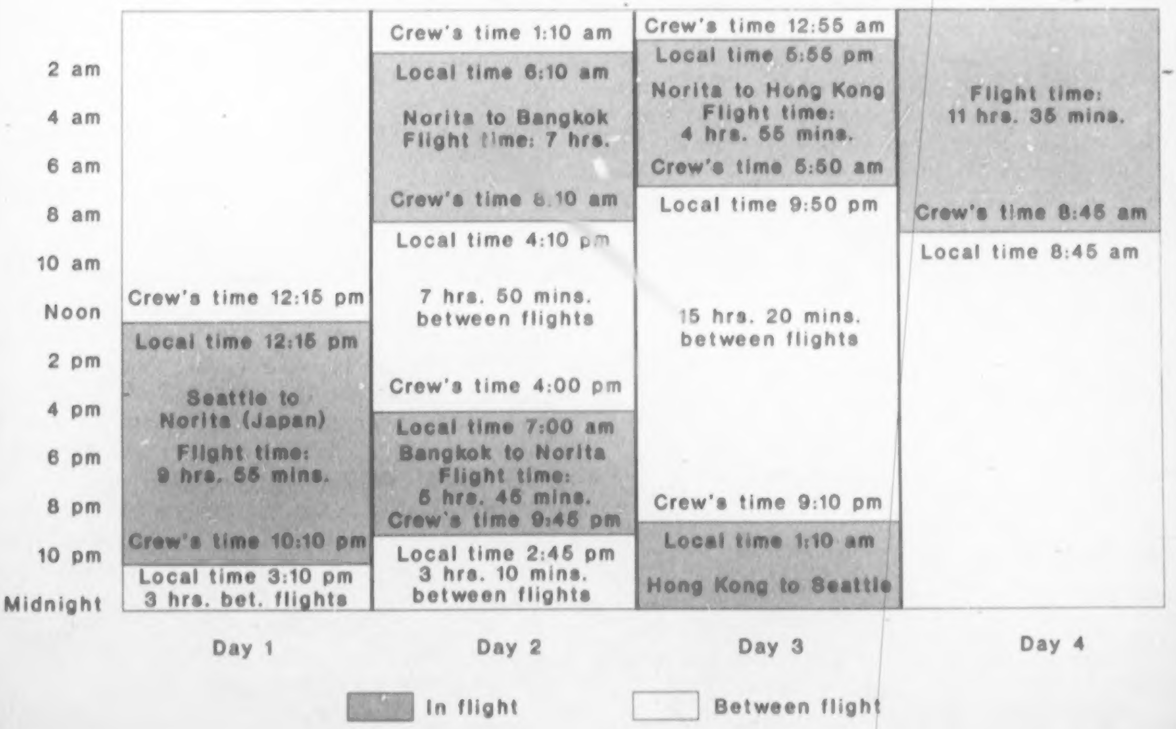
Table 4-2—Shift Work in Various Employment Sectors

Occupation or industry	Total workers employed (thousands)	Standard work schedule (percent)	Shift work (percent)			
			Evening shift	Night shift	Rotating shift	Total
Occupation						
Managerial and professional specialty	18,944	91.4	2.0	1.2	2.7	8.6
Executive, administrative, and managerial	9,079	92.6	1.8	0.8	2.6	7.4
Professional specialty	9,866	90.3	2.3	1.5	2.8	9.7
Health-diagnosing occupations	212	77.6	1.7	—	13.6	22.4
Health assessment and treating occupations	1,257	68.7	8.3	8.3	12.1	31.3
Technical, sales, and administrative support	21,961	88.3	4.2	2.1	3.5	11.7
Technicians and related support	2,548	84.5	6.5	3.3	4.6	15.5
Health technologists and technicians	761	70.1	12.5	9.0	7.6	29.9
Sales occupations	6,730	82.8	4.1	2.2	6.9	17.2
Supervisors	1,957	84.0	2.8	2.1	7.4	16.0
Salesworkers, retail and personal services	2,400	72.3	8.3	3.6	11.5	27.7
Administrative support, including clerical	12,684	92.0	3.7	1.7	1.6	8.0
Computer equipment operators	673	81.2	11.0	2.7	4.1	18.8
Mail and message distributing	613	76.2	12.7	9.1	0.4	23.8
Service occupations	7,268	61.6	16.9	6.1	8.7	38.4
Private household	275	83.0	7.3	1.9	—	17.0
Protective service	1,286	39.2	19.8	7.2	23.8	60.8
Service, except private household and protective	5,707	65.6	16.7	6.1	5.7	34.4
Food service	2,194	56.9	21.2	5.3	8.2	43.1
Health service	1,076	63.9	14.8	10.3	6.8	36.1
Cleaning and building service	1,719	74.4	16.1	5.4	1.7	25.6
Personal service	718	73.9	7.5	3.7	6.2	26.1
Precision production, craft, and repair	10,477	87.0	6.3	2.2	3.7	13.0
Mechanics and repairers	3,582	87.3	6.0	2.3	3.6	12.7
Construction trades	3,282	94.1	3.4	1.0	1.2	5.9
Other precision production, craft, and repair	3,614	80.3	9.3	3.2	6.1	19.7
Operators, fabricators, and laborers	13,326	76.3	10.5	4.6	6.2	23.7
Machine operators, assemblers, and inspectors	6,748	76.3	13.2	3.7	6.2	23.7
Transportation and material-moving occupations	3,448	73.8	5.8	6.0	7.4	26.2
Motor vehicle operators	2,392	74.5	4.3	6.9	5.9	25.5
Handlers, equipment cleaners, helpers, and laborers	3,130	78.9	9.9	5.2	4.9	21.1
Farming, forestry, and fishing	1,418	89.9	1.5	1.4	0.7	10.1
Industry						
Private sector	60,127	83.5	6.6	2.9	4.4	16.5
Goods-producing industries	24,626	85.0	7.4	2.6	3.9	15.0
Agriculture	1,154	89.4	0.9	2.2	0.2	10.6
Mining	885	78.1	6.0	1.6	12.1	21.9
Construction	4,279	97.5	1.3	0.4	0.4	2.5
Manufacturing	18,309	82.1	9.3	3.2	4.5	17.9
Durable goods	11,277	84.0	10.0	2.5	2.8	16.0
Nondurable goods	7,033	79.1	8.2	4.4	7.2	20.9
Service-producing industries	35,501	82.4	6.1	3.0	4.8	17.6

Occupation or industry	Total workers employed (thousands)	Standard work schedule (percent)	Shift work (percent)			
			Evening shift	Night shift	Rotating shift	Total
Transportation and public utilities	4,958	79.4	6.1	3.5	6.4	20.6
Wholesale trade	3,222	91.9	2.9	2.1	0.9	8.1
Retail trade	9,111	73.7	9.1	3.7	8.6	26.3
Eating and drinking places	2,242	52.4	21.0	5.3	12.5	47.6
Finance, insurance, and real estate	5,003	93.9	1.9	1.0	1.1	6.1
Services	13,207	82.9	6.4	3.3	3.9	17.1
Private household	345	80.8	7.3	1.5	0.7	19.2
Business and repair	3,242	87.4	5.8	2.4	3.1	12.6
Personal, except private household	1,379	74.0	10.1	3.8	6.6	26.0
Entertainment and recreation	529	66.6	13.8	2.2	7.3	33.4
Professional services	7,682	83.8	5.4	3.7	3.6	16.2
Hospitals	2,303	73.0	10.5	6.6	8.5	27.0
Public sector	13,268	87.2	4.6	2.0	3.7	12.8
Federal Government	2,901	86.2	6.1	3.4	2.8	13.8
State government	3,320	88.2	4.3	2.3	3.0	11.8
Local government	7,047	87.1	4.2	1.3	4.5	12.9

SOURCE: E.F. Mellor, "Shift Work and Flexitime: How Prevalent Are They?" *Monthly Labor Review* 109:14-21, 1986.

Figure 4-3—Four Days With an International Flight Crew


2 am
4 am
6 am
8 am
10 am
Noon
2 pm
4 pm
6 pm
8 pm
10 pm
Midnight
Crew's time 12:15 pm
Local time 12:15 pm
Seattle to Norita (Japan)
Flight time: 9 hrs. 55 mins.
Crew's time 10:10 pm
Local time 3:10 pm
3 hrs. bet. flights
Crew's time 1:10 am
Local time 6:10 am
Norita to Bangkok
Flight time: 7 hrs.
Crew's time 8:10 am
Local time 4:10 pm
7 hrs. 50 mins. between flights
Crew's time 4:00 pm
Local time 7:00 am
Bangkok to Norita
Flight time: 5 hrs. 45 mins.
Crew's time 9:45 pm
Local time 2:45 pm
3 hrs. 10 mins. between flights
Crew's time 12:55 am
Local time 5:55 pm
Norita to Hong Kong
Flight time: 4 hrs. 55 mins.
Crew's time 5:50 am
Local time 9:50 pm
15 hrs. 20 mins. between flights
Crew's time 9:10 pm
Local time 1:10 am
Hong Kong to Seattle
Flight time: 11 hrs. 35 mins.
Crew's time 8:45 am
Local time 8:45 am
Day 1
Day 2
Day 3
Day 4
▨ In flight
□ Between flight

International trip schedule for a single flight crew.

SOURCE: Courtesy B. Edmunds, Airline Pilots Association, 1991.

occupations (8).[9] **More than 38 percent of those employed full-time in service occupations are shift workers, compared to the average of 15.9 percent for all full-time employed persons.** This prevalence of shift work in service occupations holds true among some professional groups; while only 9.7 percent of full-time professionals overall are shift workers, 22.4 percent of full-time professionals in health-diagnosing occupations (e.g., doctors and dentists) are shift workers, as are 31.3 percent of professionals in the health assessment and treatment occupations (e.g., registered nurses and therapists) (table 4-2).[10] Some subgroups among the service sector exhibit an extremely high prevalence of shift work. For example, 60.8 percent of full-time protective service workers (e.g., police and firefighters) are employed during nonstandard hours. Among persons employed in service-producing industries, those employed in eating and drinking places (47.6 percent) and in entertainment and recreation (33.4 percent) are especially likely to be shift workers.

Technological advances and the increased importance of global communication and interaction have become powerful incentives for the addition of a second and third shift. BLS reported that **between 1978 and 1985, the number of clerical personnel working at night increased three times faster than the number of all other night workers (4).** Night work among technical and professional office personnel increased 36 percent during this period. Competitive pressures, either to accelerate information processing and the services provided by these industries or to conduct business in different time zones, are important factors in the increased hours of work in the office environment. The high cost of office automation equipment and large computer centers may lead to an increase in the hours of operation in order to make the best use of the investment. Night hours may also be established to take advantage of less expensive and more readily available computer time from computer programming and data analysis services (10).

Who Are Shift Workers?

Shift work may have different health and social effects on men as compared to women, single as compared to married persons, and parents as compared to nonparents. In fact, some of the advantages and problems associated with shift work have been attributed to marital and child-care responsibilities. This section presents demographic data on the prevalence of shift work among men, women, married persons, and persons with child-rearing responsibilities.

Analysis of data from the CPS supplements and other sources noted above yields an assessment of the personal characteristics of shift workers in relation to regular daytime workers (comparisons based on self-reporting of full-time wage and salary earners in 1985) (8) (table 4-3). Among full-time employed men, 27.4 percent between the ages of 16 and 19, compared to 14.6 percent age 45 and over, do not work a regular daytime schedule (8). Thus, younger men are more likely to work nonstandard schedules than older men. Also, single men are more likely to be shift workers than married men. Among full-time employed single and married men, 21.1 and 16.5 percent, respectively, work nonstandard hours. Black men are more likely to work nonstandard hours: approximately 22.6 percent of full-time employed black men are shift workers, compared to 17.3 percent of white men. There is little difference in frequency of shift work between whites and persons of Hispanic origin. **Although young, single, and black men are more likely to be shift workers, older, married, and white men, being the majority of full-time workers, form the majority of shift workers.**

Gender differences in shift work prevalence depend on whether full-time or part-time work is considered. Considering only full-time wage and salary earners age 16 and over (based on self-reporting), the BLS reports that 17.8 percent of men and 13.0 percent of women are shift workers (8) (table 4-3). Since women are more likely than men to work part-time, gender differences are not substantial when all employed persons, part-time and full-time, are considered. As of May 1985 (based on actual work hours), 20.3 percent of men and 17.1 percent of women age 18 and over in nonagricultural occupations were shift workers (15). **Men are more likely than women to work night, miscellaneous, and rotating shifts, whereas women are more likely than men to work the evening shift (14).**

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[9] Note that the BLS reports this only for full-time wage and salary earners, and it is based on the respondent's designation of the shift worked.

[10] Shift work prevalence and patterns in the health professions are considered in detail in ch. 8.

Table 4-3—Demographic Profile of Shift Workers

Characteristic	Total workers employed (thousands)	Standard work schedule (percent)	Shift work (percent)			
			Evening shift	Night shift	Rotating shift	Total
Age						
Men, 16 years and over	43,779	82.2	6.8	3.0	4.9	17.8
16 to 19	1,139	72.6	11.8	4.7	7.0	27.4
20 to 24	5,567	80.0	8.5	3.5	5.0	20.0
25 to 34	14,281	80.0	7.8	3.3	5.6	20.0
35 to 44	10,630	83.6	5.7	2.7	5.0	16.4
45 to 54	7,094	85.4	5.3	2.7	3.9	14.6
55 to 64	4,594	85.5	5.6	2.1	3.8	14.5
65 and over	474	85.4	2.8	2.5	4.0	14.6
Women, 16 years and over	29,616	87.0	5.5	2.3	3.3	13.0
16 to 19	777	71.1	12.8	4.0	9.4	28.9
20 to 24	4,346	84.0	6.7	2.0	5.1	16.0
25 to 34	9,510	87.5	5.3	2.2	3.3	12.5
35 to 44	7,080	88.9	4.8	2.3	2.2	11.1
45 to 54	4,753	88.4	4.6	2.2	2.8	11.6
55 to 64	2,838	87.3	5.3	2.6	3.2	12.7
65 and over	311	85.8	7.3	3.8	—	14.2
Total, 16 years and over	73,395	84.1	6.3	2.7	4.3	15.9
Race and Hispanic origin						
White	63,523	84.7	5.8	2.6	4.3	15.3
Men	38,588	82.7	6.3	2.9	5.0	17.3
Women	24,935	87.8	5.0	2.1	3.3	12.3
Black	7,847	80.1	9.8	3.5	4.3	19.9
Men	4,054	77.4	10.6	3.7	5.3	22.6
Women	3,793	83.0	8.9	3.2	3.2	17.0
Hispanic origin	4,911	84.6	7.1	2.5	3.3	15.4
Men	3,184	82.3	7.7	2.8	4.0	17.7
Women	1,727	88.8	5.8	1.9	2.0	11.2
Marital status						
Men						
Single, never married	9,703	78.9	9.3	3.6	5.0	21.1
Married, spouse present	29,666	83.5	5.7	2.7	5.1	16.5
Widowed, divorced, or separated	4,410	80.4	8.5	3.6	4.0	19.6
Women						
Single, never married	7,109	83.6	6.8	2.3	5.2	16.4
Married, spouse present	15,679	89.9	4.3	1.9	2.3	10.1
Widowed, divorced, or separated	6,828	83.7	7.0	3.3	3.6	16.3

SOURCE: E.F. Mellor, "Shift Work and Flexitime: How Prevalent Are They?" *Monthly Labor Review* 109:14-21, 1986.

A detailed analysis of the job characteristics of female shift workers, based on the May 1985 CPS, included women age 18 and over employed in various occupations and industries, both full- and part-time (15). It therefore focused on the seven occupations with the highest percentage of women working fixed nights, namely (in rank order), registered nurses, nurses' aides, practical nurses, food preparation and service workers, textile operators, janitors, and cashiers. Over half (58.9 percent) the women who worked fixed nights were employed in these seven occupations, and close to half of them worked evenings (49.1 percent) or a rotating shift (42.1 percent). In contrast, only 14.8 percent of those who worked fixed days and 19.4 percent of those who worked a miscellaneous shift (more than 12 hours a day, including split shifts) were in these occupations. As for industry, 48.3 percent of all women who worked fixed nights in 1985 were in medical services, compared to 18.0 percent who worked fixed evenings, 20.5 percent who worked rotating shifts, 9.0 percent who worked miscellaneous shifts, and 11.2 percent who worked fixed days. Among all employed women, 12.9 percent were in medical services, compared to 3.2 percent of all employed men.

Since the CPS collects similar data on all household members, it is possible to consider the work schedules of husbands and wives jointly when both are employed (dual-earner couples). From the perspective of a couple, the prevalence of shift work is high. Based on the May 1980 CPS data, one-fourth of all dual-earner couples without children and one-third of all dual-earner couples with children included at least one spouse who did shift work (12). An analysis of the May 1985 data for dual-earner couples with children showed a similar proportion (one-third) (16).

A study of full-time dual-earner couples, based on the May 1980 CPS, showed that although employed wives are more likely than employed husbands to be service workers, service work produces a higher likelihood of shift work among husbands (50.7 percent) than wives (30.3 percent) (12). Within service occupations, the highest prevalence of shift work for husbands was among protective service workers (66.0 percent); the highest prevalence for wives was in health service (36.7 percent).

Given that couples who are young and couples who have children are more likely to work nonstandard hours, it is not surprising to find a remarkably high prevalence of shift work among young dual-earner parents with children under age 5. It is estimated that about 50 percent of all young couples with children under the age of 5 in the United States include at least one spouse who works nonstandard hours (13). This estimate is based on an analysis of the parents in the National Longitudinal Study, Youth Cohort, as of 1984, when they were age 19 to 26. Among those employed full-time, mothers were about as likely as fathers to work nonstandard shifts (29.0 and 30.2 percent, respectively), but there were differences in the type of shift: fathers were more likely than mothers to work fixed nondays (19.1 percent and 14.8 percent, respectively), and mothers were more likely than fathers to work a rotating schedule (14.2 percent and 11.1 percent, respectively). Over one-fourth of all part-time employed mothers in this sample (26.9 percent) were on rotating schedules, and an additional 14.7 percent were fixed nonday workers; accordingly, about two-fifths of part-time employed mothers were nonday workers.

An analysis of shift work among women age 18 to 44 with pre-school age children, based on the June 1982 CPS, showed that the prevalence of shift work was considerably higher among unmarried than married mothers (11). Thus, among persons with children, it is both young dual-earner parents and unmarried employed mothers who are especially likely to be working nonday hours. Whether these particular subgroups are increasing is unknown.

WHY DO EMPLOYEES PERFORM SHIFT WORK?

The previous discussion provides evidence that shift work has a broad demographic sweep, including people of differing age, gender, marital status, and type of employment. The diversity of individuals working nonstandard schedules suggests that the motivation, concerns, and needs of these workers are not uniform. In the following section, the reasons individuals give for working nonstandard schedules are discussed.

Why do employees perform shift work? Some workers prefer nonday work. A survey of workers from four plants found that most of the permanent night shift workers prefer to work that shift (22). Data from the May 1985 CPS, however, suggest that many individuals do not prefer shift work. Respondents were asked their main reason for working a nonday shift. Answers were coded into subsets of voluntary and involuntary reasons. Voluntary reasons included better child-care arrangements, better pay, better arrangements for care of other family members, and more time to attend school. Involuntary reasons included inability to get any other job and requirement of the job. The BLS reported that only 28 percent of persons not working a regular daytime schedule gave a voluntary reason (e.g., to accommodate child care); 72 percent gave involuntary reasons, and 90 percent of these said the schedule was a job requirement (8).

An analysis of full-time, dual-earner couples in the May 1980 CPS also indicates that the type of employment is exceedingly important in determining an individual's schedule (12). In this study, occupational and industrial differences in shift work were more pronounced than personal characteristics such as age, race, union membership, or multiple jobs.

A separate analysis of dual-earner couples with children considered the reasons why parents were working nonday schedules (16). It was found that fathers and mothers differ considerably in their main reasons for doing so. For only a small minority of

fathers the primary reason for working nondays is child care (5.6 percent) or other family caregiving (2.5 percent), compared to close to a majority of mothers (34.3 percent for child care and 12.3 percent for other family caregiving). Better pay is not a common reason for either gender, although it is more relevant for fathers than mothers.

Among these dual-earner couples, the main reason for working nonstandard hours varies by type of shift as well as gender. Clearly, it is difficult to provide care to family members on a regular basis when one works a rotating shift. **Thus, persons who work fixed nondays are more likely than persons on a rotating shift to do so primarily in order to care for children or other family members, including the elderly.** As might be expected, the age of the youngest child is important: child care is most likely to be the reason for working nonday hours when employed wives have children under the age of 6 (41.9 percent) (16).

SHIFT WORK SCHEDULES

While the traditional work schedule is typified by 40 hours of work during the daylight hours, an increasing variety of work schedules is in place in the United States (3,6,18). Shift work schedules involve working hours outside the standard workday (8 a.m. to 4 p.m.) (21). **The Federal Government does not collect data characterizing specific shift work schedules employed by occupations and industries in the United States.** Although the samples used in the national studies that ask scheduling questions ~~are large, the~~ actual number of shift workers in the samples is not sufficiently large to analyze the different types of schedules. Furthermore, private industry and labor representatives do not formally collect data concerning shift work and schedules (20). The dearth of information concerning shift work schedules has led researchers to conclude that:

> . . . neither trade organizations nor labor unions maintain quantitative data on the type and distribution of shift work practices in their industries. Even where information on shift schedules was available, it was cumbersome and complex. . . . More comprehensive data were maintained by the Bureau of Labor Statistics (BLS) . . . although this information . . . is woefully inadequate for characterizing industries by types and distribution of shift systems (1).

Available information suggests that several hundred shift routines are in place in the United States (3,18). Several factors contribute to this variation. Schedules vary significantly among industries and occupations and according to the type of work performed. Since shift schedules are generally determined at individual work sites, diverse schedules are found even within a single industry, reflecting geographic and regional differences (table 4-4). Work schedules are also influenced by certain laws and regulations (see ch. 6). The Fair Labor Standards Act of 1938 established the standard 40-hour workweek that now covers nearly 60 percent of all wage and salary workers and is part of the social norm (18). Another standard has been derived from many Federal and State statutes, as well as union contracts: the 8-hour day. These legal standards bear particularly on schedules involving a compressed workweek (box 4-A), extended duty hours, and overtime (box 4-B). Tradition in a particular occupation or industry, labor costs, and availability of skilled labor also influence the type of shift system in place at a work site.

Research suggests that the most common shift schedule in the United States, especially in the manufacturing sector, involves working 5 days on a single shift, followed by 2 days off (2,7). Such a schedule can involve 8- or 12-hour shifts and 3 (day, evening, and night) or 2 (day and evening or day and night) shifts per day, which may be fixed, rotating, or a combination of the two (partially fixed). Shift work systems are also employed to cover 7 days a week of continuous operation, such as in the service sector or in continuous-process manufacturing. Again, the length of the scheduled workday may range from 8 to 12 hours. Shifts may be fixed, partially fixed, or rotating. Shift rotation may be rapid (3 days) or long (4 weeks); it may proceed forward (day, evening, night) or backward (day, night, evening). Other types of shift scheduling exist, and these may be increasing in popularity. For example, the compressed workweek, in which employees work approximately 40 hours in fewer than 5 days, is common in certain employment sectors, and its use may be expanding (see box 4-A). Irregular scheduling, in which shifts are variable and erratic, is used in some employment sectors, including the transportation and manufacturing industries (figures 4-2 and 4-3). While data have not been collected to document this work practice, labor representatives have

Table 4-4—Three Mills and Their Schedules

5-week rotational 8-hour shift schedule: Cosmopolis, WA—pulp/paper mill (week 5 is a repeat of week 1)

Shift	Time
Day	7:30 a.m. to 3:30 p.m.
Evening	3:30 p.m. to 11:30 p.m.
Night	11:30 p.m. to 7:30 a.m.

Letters A through D represent groups of workers.

	Week 1							Week 2							Week 3							Week 4						
	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	T	S	S
Day	D	D	D	D	D	A	A	A	A	A	A	A	B	B	B	B	B	B	B	C	C	C	C	C	C	C	D	D
Evening	B	B	C	C	C	C	C	C	C	D	D	D	D	D	D	D	A	A	A	A	A	A	A	B	B	B	B	B
Night	A	A	A	A	B	B	B	B	B	B	B	C	C	C	C	C	C	C	D	D	D	D	D	D	D	A	A	A
Off	C	C	B	B	A	D	D	D	D	C	C	B	A	A	A	A	D	D	C	B	B	B	B	A	A	D	C	C

Fixed-shift 8-hour schedule: operate 7 days/week: Adel, GA—panel mill (employees do not rotate—week 5 is a repeat of week 1)

Shift	Time
D = Day	7 a.m. to 3 p.m.
E = Evening	3 p.m. to 11 p.m.
N = Night	11 p.m. to 7 a.m.
R = Relief worker	
O = Off	

	Week 1							Week 2							Week 3							Week 4						
	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	T	S	S
Day	D	O	O	D	D	D	D	D	D	D	O	O	D	D	D	D	D	D	D	O	O	O	D	D	D	D	D	D
Evening	O	E	E	E	E	E	E	E	O	O	E	E	E	E	E	E	E	O	O	E	E	E	E	E	E	E	O	O
Night	N	N	N	N	N	O	O	O	N	N	N	N	N	O	N	O	O	N	N	N	N	N	N	N	O	O	N	N
Relief	R	R	R	O	O	R	R	R	R	R	R	R	O	O	O	R	R	R	R	R	R	R	O	O	R	R	R	R

5-week rotational 12-hour shift schedule: Valliant, OK—pulp/paper mill (week 5 is a repeat of week 1)

Shift	Time
Day	7 a.m. to 7 p.m.
Night	7 p.m. to 7 a.m.

Letters A through D represent groups of workers.

	Week 1							Week 2							Week 3							Week 4						
	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	T	S	S
Day	D	D	D	D	B	B	B	A	A	A	A	C	C	C	B	B	B	B	D	D	D	C	C	C	C	A	A	A
Night	B	A	A	A	C	C	C	C	B	B	B	D	D	D	D	C	C	C	A	A	A	A	D	D	D	B	B	B
Off	C	C	C	C	D	D	D	D	D	D	D	A	A	A	A	A	A	A	B	B	B	B	B	B	B	C	C	C
Off	A	B	B	B	A	A	A	B	C	C	C	B	B	B	C	D	D	D	C	C	C	D	A	A	A	D	D	D

SOURCE: M. Waters, Weyerhaeuser Co., Tacoma, WA, 1990.

indicated to the Office of Technology Assessment (OTA) their concern about its increasing use (23).

How specific shift work schedules are selected at individual work sites in the United States has not been carefully documented. Schedules may be dictated by management or, more commonly, derived from discussion between management and unionized or nonunionized employees. Clearly, the absence of information concerning specific shift work systems and how they are derived handicaps the study of the health, performance, and social effects of shift work, as well as the derivation of sound shift work policies.

SUMMARY AND CONCLUSIONS

Shift work, a required dimension of work in any industrially developed country, encompasses a wide range of nonstandard work schedules, including evening work, night work, split or extended shifts, and rotating shifts. While national data indicate that shift work is prevalent, there are large gaps in these data. OTA finds that the Federal Government's collection of data pertaining to the prevalence and use of shift work has not been consistent.

The most recent and comprehensive data, collected by the BLS in 1985, indicate that one out of

Box 4-A—The Compressed Workweek

The compressed workweek (CWW) refers to a schedule in which employees work approximately 40 hours in fewer than 5 days. A variety of schedules, with a variety of rationales, can be said to constitute a CWW. Typically, work is performed 10 or 12 hours per day, 3 or 4 days per week, and 3 or 4 days per week are free. Other possibilities include a long break schedule; for example, a schedule of 12-hour shifts may employ a sequence of 4 days on duty, 7 days off duty, 4 days on, 3 days off, 3 days on, 1 day off, 3 days on, and 3 days off. As with all types of shift work, national data on the prevalence of specific CWW schedules are not available.

The CWW with 12-hour shifts appears to be common in the chemical industry (including petrochemical), the petroleum industry, offshore oil rigs, and ministeel industries. Other types of employment that could adopt the CWW include the paper industry, other manufacturing processes, utility industries (including nuclear powerplants), nursing and other health fields, clerical work, administrative work, technical maintenance, and computer operations.

Information derived from management and employee comments, limited psychological testing, and performance and safety records has highlighted some of the advantages and disadvantages of the CWW (table 4-5). In general, the CWW appears to increase worker satisfaction because it allows more days and weekends off. For example, in one plant, conversion to a CWW schedule with 12-hour shifts reduced the number of days on the job each year from 273 to 182. Also, when the CWW has 12-hour rotating shifts, fewer consecutive days are spent on the night shift and there is more time to recuperate than with 8-hour shifts 5 days a week. This may lessen the fatigue associated with rotating shifts and night work (see ch. 5). While more days off may improve employee satisfaction, concerns about increased moonlighting have been voiced and have been documented in one case. In general, however, studies have failed to document an increase in moonlighting.

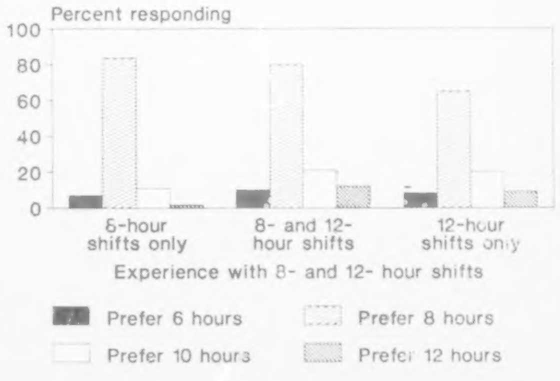
Data have suggested that not all employees endorse the CWW. Family responsibilities and previous work experience appear to influence preference for the CWW (see figure 4-4). One study estimated that 28 percent of work sites adopting a CWW will revert to the standard 8-hour day, 5-day week schedule. A few studies have indicated that women, especially those with young children, and older employees may be less satisfied with a CWW.

The use of the CWW, especially with two 12-hour shifts replacing three 8-hour shifts, may be more cost-effective for employers, since the number of shift changes is decreased (shift changes are the least productive time in an operation). Absenteeism also appears to be diminished when the CWW is adopted. Replacement of absent employees, however, may be more difficult with this schedule, since one common way of replacing an absent employee is holding over another from a previous shift, which is ill-advised for shifts of 12 hours.

Concerns over performance and safety have been voiced in relation to the CWW, although few studies have analyzed this issue (see ch. 5). It has been suggested that fewer errors and accidents occur and productivity improves on CWW schedules. Other studies suggest that a 12-hour day, 4-day week produces more fatigue and poorer sleep and psychomotor performance than an 8-hour day, 5-day week.

Administrative problems may arise from the use of the 12-hour shift and the CWW. Since laws and regulations regarding hours of work are generally based on the 8-hour day and 40-hour workweek, computation of hourly wage and vacation time must be adjusted. Similarly, since exposure limits to noise, chemicals, and heat are generally based on the 8-hour day, they may need to be recalculated.

Figure 4-4—Shift Work History and Preference



Data drawn from a study of 2,115 hourly and salary workers employed at four industrial sites.

SOURCE: D. Tepas, "Condensed Working Hours: Questions and Issues," *Studies in Industrial and Organizational Psychology. Shiftwork: Health, Sleep and Performance*, vol. 9, G. Costa, G. Cesana, K. Kogi, et al. (eds.) (Frankfurt am Main: Verlag, Peter Lang, 1989).

SOURCE: Office of Technology Assessment, 1991.

Table 4-5—Potential Advantages and Disadvantages of 12-Hour Schedules

Factor	Advantage	Disadvantage
Most workers like it, which could result in:		
• Increased job satisfaction; less difficulty in recruiting new personnel	X	
• Improved employee morale	X	
• Decreased absenteeism due to proportionate loss of pay	X	
• Sleep time more easily adjusted to two shifts instead of three shifts	X	
• Decreased attrition (decreased training cost, more experienced operators)	X	
More days off and more consecutive days off		
• Workers like days off and weekends off (75 to 85 more days off)	X	
• There is more time with family, leisure time, time to conduct personal business	X	
• Workers take less personal time off	X	
• Workers lose touch with operations		X
• Workers might be tempted to moonlight, travel great distances, or engage in exhausting recreation on consecutive days off and return to work fatigued		X
Shift turnovers reduced from 3 per day to 2 per day		
• Reduced number of communication errors during shift turnover	X	
• Improved continuity of operations	X	
• More chance that the crew that begins a maintenance job or begins an evolution will be the same crew that ends it. This contributes to quality work and job satisfaction.	X	
• Reduction in commute time and commute cost by about one-third.	X	
Within any 1 day, 12 hours of work is more fatiguing than 8 hours of work		
• Alertness and safety might decline		X
• Because the day is longer, workers might work at a slower pace		X
• Workers need more breaks		X
• 8-hour night shifts are difficult; 12-hour night shifts are more difficult		X
• 12-hour shifts might be more difficult for older workers		X
Over several consecutive days, 12 hours of work per day is more fatiguing than 8 hours of work per day		
• Less time for rest exists between consecutive workdays; fatigue might accumulate		X
• Fewer consecutive workdays and more rest days will dissipate fatigue	X	

SOURCE: Adapted from U.S. Nuclear Regulatory Commission, *NUREG/CR-4248 Recommendations for NRC Policy on Shift Scheduling and Overtime at Nuclear Power Plants* (Richland, WA: Pacific Northwest Laboratory, 1985).

five full-time workers—approximately 20 million Americans—is a shift worker. Approximately 2.0 million individuals are night workers, and 3.1 million people work rotating shifts, which may involve night work. These individuals are most likely to be employed in capital-intensive manufacturing industries, transportation, and service industries.

Shift work is done by 17.8 percent of men and 13.0 percent of women employed full-time. Data indicate that young, single, and black men are more likely to be shift workers; however, older, married, and white men, being the majority of full-time workers form the majority of shift workers. While men are more likely than women to be shift workers, shift work is highly prevalent among women in some employment sectors, including nursing and health services. Data suggest that shift work affects many families, especially those with young children. It is estimated that 50 percent of all young, dual-earner couples with children under the age of 5 include at least one spouse who works nonstandard hours.

There are hundreds of different shift work schedules in place. However, data concerning the specific properties of shift work schedules, such as the involvement of night work, shift length, the number of consecutive days worked, and the use of rotating shifts, have not been collected by the Federal Government, labor representatives, or industry. The absence of such data severely handicaps the study of the health, performance, and social effects of shift work, as well as changes in trends concerning the use of shift work.

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Box 4-B—40 Hours Plus: Overtime and Moonlighting

Overtime and moonlighting have always played a significant role in American industry. As is the case with shift work, working extended hours at one or more jobs may raise performance and safety questions (see ch. 5).

The supplement to the May 1985 Current Population Survey (CPS) provides information on the prevalence and demography of overtime work. From these data, the BLS estimated that 21.4 million persons work more than 40 hours per week at one job. It was further estimated that 10.5 million Americans receive premium pay for overtime work, usually at the rate of one-and-a-half times their normal pay. With few exceptions, individuals receiving premium pay for overtime worked more than 40 hours a week: further, they averaged 9.6 hours of overtime. Nearly two-thirds of these employees reported working 1 to 8 hours beyond 40 hours; 16 percent reported 16 hours or more beyond 40 hours.

Overtime compensation was more common in certain occupations, including precision production, craft and repair, and operators, fabricators, and laborers. These groups account for more than half of all workers receiving premium pay for overtime. Within industry groups, mining, manufacturing, transportation, public utilities, and construction most commonly receive premium overtime pay. Of the approximately 60 percent of employees not being compensated for work beyond 40 hours per week, most were in managerial, professional, technical, sales, and administrative support jobs, which are outside the provisions of the Fair Labor Standards Act (see ch. 6).

Overtime may be used by employers to meet unexpected or excessive short-term demand, to fill in for absent workers, or, when used regularly, as a cost-saving device (i.e., it costs less to pay overtime premiums than to hire new workers, with their pensions, sick leave, and health insurance benefits). Data indicating the extent to which overtime work is voluntary or mandatory for employees are lacking.

A supplement to the May 1989 CPS survey addressed the issue of holding more than one job, or moonlighting. In this survey the CPS defined a moonlighter as an employed person who 1) had a wage- or salary-paying job with two employers or more, 2) was self-employed and also held a job paying a wage or salary, or 3) worked as an unpaid family worker on the primary job (the one at which the greatest number of hours are worked) and had a secondary job paying a wage or salary.

It was estimated that 7.2 million persons hold two or more jobs, which is a 52 percent increase from 1980. Among men, 4.1 million, most of them married, moonlight. Of men with more than one job, 82.8 percent hold one full-time job and one part-time job; 11.3 percent hold two part-time jobs; and 5.8 percent work two full-time jobs. On average, men holding two jobs work a total of 55.8 hours per week.

This survey indicated a sharp increase in the number of women working multiple jobs. Some 3.1 million women hold more than one job, averaging 47.1 hours of work per week. Women make up 43 percent of all persons holding multiple jobs, in contrast to an estimated 15 percent in 1970. Among women who moonlight, 64 percent hold one full-time job and one part-time job; 33 percent hold two part-time jobs; and 2.9 percent hold two full-time jobs. Most women with more than one job were widowed, divorced, or separated.

Individuals work more than one job for various reasons. Among the reasons were the following: to meet regular expenses (35.5 percent); to pay off debts (8.9 percent); to save for the future (16.2 percent); and to gain experience in a different occupation (14.7 percent). The highest rates of moonlighting were found in public administration (8.8 percent), service industries (7.8 percent), educational services (11.1 percent), and male protective service workers (11.8 percent).

SOURCES: D.E. Carr, "Overtime Work: An Expanded View," *Monthly Labor Review* 109:36-39, 1986; J.F. Stinson, Jr., "Multiple Job Holding Up Sharply in the 1980s," *Monthly Labor Review* 113:3-10, 1990.

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Chapter 5

Biological Rhythms and Work Schedules

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METHODOLOGY

Because the effects of work schedules are sometimes subtle and involve a number of factors, they can be difficult to study. Frequently, the most important variables are those that occur outside the workplace (e.g., quality of sleeping during the day, social effects), thus research relies to a large extent on self-report and anecdotal information. Three basic classes of studies have been used to examine effects of work schedules: 1) field studies, 2) survey studies, and 3) laboratory studies.

Field studies, in which the researcher studies subjects in their actual work environment, are comparatively rare in the world literature and largely absent from the U.S. literature because of the high cost and difficulty of getting substantive physiological, production, or subjective measures from a group of workers for a reasonable period of time (e.g., one complete cycle of a rotating shift schedule). Field studies often have a small sample size and require a dedicated group of volunteer subjects if circadian rhythm or sleep variables are to be measured properly. Such studies can provide an invaluable picture of what is happening to the sleep, circadian rhythms, and performance of shift workers under various conditions. An example of field studies that have been carried out in the United States are those conducted by the National Aeronautics and Space Administration (NASA) on fatigue, sleep, and circadian rhythms in flight crews. Field studies in other occupations have been carried out in Sweden (5), West Germany (84), the United Kingdom (158), and France (129).

Physiological measures taken in field studies are typically in the domains of circadian rhythms and sleep. Body temperature is the preferred variable in measures of circadian rhythms because it is easily measured and reliable in indicating the status of the circadian system. Ideally, sleep is measured by directly monitoring physiological functions (e.g., brain activity, eye movements, muscle activity) during sleep, but this is often impractical, so subjective measures, such as sleep diaries or sleep questionnaires, are used. Another method, which has been used more recently, is wrist activity monitors worn by workers to collect information on activity levels, from which amounts of sleep are inferred (128). Mood, social and family factors, and performance can be measured by self-report tests, sometimes augmented by measures of on-the-job performance.

Survey studies are considerably easier to conduct and usually involve questioning the worker in one or two interviews or classroom-type sessions. These data are augmented by data from personnel, health service, and absenteeism files and a review of production figures. Neither circadian rhythm nor sleep diary measures can be obtained directly in survey studies. Data on these variables are gleaned from questions about perceived levels of alertness while on duty and average timing and quality of sleep after various shifts. Survey studies are often carried out before and after an intervention in order to assess its impact (36). Contamination by placebo effects,[1] which can endanger the validity of outcomes, is a problem that needs to be carefully controlled for in survey studies (116).

Laboratory studies attempt to simulate the workplace in a controlled situation. In some cases, workers are used as subjects, but since that is often impractical, studies usually use other individuals as subjects (86,175). The major advantage of laboratory studies is that they are the best way to get accurate, clear, and complete recordings of sleep and circadian rhythms (and mood and performance measures) without all of the interference and missing of readings that are so characteristic of field studies. The disadvantage is that some factors that play a role in the real work situation (e.g., social and domestic strains, the length of exposure to the schedule being studied) and the types of stress experienced may not be replicated exactly. Another important consideration in laboratory studies is the nature of the task the subject is to perform. In some cases, when general information about the effects of a work schedule on variables such as performance, alertness, and vigilance is desired, standardized tasks and tests can be used. However, in studies of the effects of a schedule on a specific type of job, simulators are used to recreate the work environment. For example, simulators that replicate an aircraft cockpit, a nuclear powerplant control room, or an air traffic control tower are effective aids in the study of the effects of work schedules on worker performance during specific job-related tasks.

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[1] The placebo effect is when an intervention that has no real, direct action results in an effect, e.g., when a subject reports feeling better after having been given a sugar pill. The effect is due not to the intervention, but to the subject's anticipating an effect from the intervention.

Chapter 5

Biological Rhythms and Work Schedules

As discussed in chapter 3, disruption of biological rhythms can result in physiological changes that adversely affect both health and performance. In the workplace, certain types of work schedules can require persons to work at inappropriate points in the circadian cycle and cause disruptions of biological rhythms, notably circadian rhythms. However, in these situations, the physiological changes caused by disruption of circadian rhythms often interact with other stressors associated with work schedules (fatigue, sleep deprivation, and social or domestic stress) to compound the effects. This chapter discusses these interactions, their consequences, and possible interventions to prevent them.

WORK SCHEDULES

The characteristics of work schedules that can be varied include the length of the work period, the placement of the work period in the 24-hour day, the regularity of that placement, the speed at which the placement changes, and the ratio of work time to rest time. **Any schedule that requires workers to work when they would normally be sleeping (and sleeping when they would normally be awake) can disrupt circadian rhythms** (31). This includes schedules that require workers to constantly change the hours that they work or to work for extended periods of time.

Shift work is not new (103,144). Historically, bakers have worked through the night to ensure fresh bread in the morning, and in ancient Rome deliveries were restricted to the night hours in order to relieve traffic congestion. With the initiation of the Industrial Revolution, more and more work processes required full-time operation. Since then, there has been an increase in the prevalence of shift work as industrial needs for 24-hour operations combined with more and more service industries providing evening or around-the-clock coverage.

As described in chapter 4, a variety of shift schedules are used in work settings, including schedules of fixed or rotating shifts. **In a rotating shift schedule, the individual works one shift for a period of time before rotating to the next shift. Thus, the person will frequently be changing the scheduled hours he or she works. In a fixed shift schedule, the worker always has the same work hours.**

Work that continues for long periods of time (i.e., usually beyond 12 hours) and causes workers to decrease or miss their normal sleep is considered extended duty hours. Often there is not a clear distinction, or there is overlap, between shift work and extended duty hours. For example, workers on a rotating shift schedule may work overtime, exposing them to both extended duty hours as well as the rotating shift. Extended duty hours can lead to disruptions in circadian rhythms that interact with other factors, especially loss of sleep and fatigue, to affect health and performance. (Sleepiness is the inclination to sleep, whereas fatigue is weariness due to physical and mental exertion.) It is possible to experience one without the other, but both, either alone or in concert, can have deleterious effects. This is especially true if such work schedules are consistently marked by extended work periods interspersed with relatively short rest periods and are irregularly scheduled. Examples of occupations that involve extended duty hours are medical and surgical residencies at hospitals, military operations, long-haul trucking runs, and any setting in which there is frequent overtime work.

Photo credit: Paul E. Cooper

Availability of 24-hour services is becoming more prevalent.

STRESSORS CAUSED BY WORK SCHEDULES

Human beings are essentially diurnal creatures, whose internal clocks are naturally geared toward sleep and inactivity at night and activity and wakefulness during the day. Because of this, the vast majority of human society is structured with the expectation that work will be done during the day, recreation in the evening, and sleep during the night. Morning and evening rush hours are catered to by mass transit; prime-time television, sports events, and social gatherings occur in the evening; and a quiet environment is enforced at night. Social taboos, for example, protect a day worker's sleep from nonemergency telephone calls at 2 a.m., but none protects a night worker's sleep from 2 p.m. calls. Thus, the shift worker is very often fighting both the natural diurnal trend and sociocultural attitudes.

Consequently, there are three sources of stress, or stressors, for the shift worker:

- disruption of circadian rhythms,
- disruption of sleep and fatigue, and
- social and domestic disturbances.

These stressors act alone and in combination to produce adverse effects on the worker. The first two are physiological effects associated with the hours of work and the length of the work period. The third can result from the worker's interactions at home and with the rest of society as a result of the work schedule. **How much stress these three sources place on the worker varies with the nature of the work situation and the work schedule.** For the person working extended duty hours, sleep loss and fatigue may be the most salient factor, while for the rotating shift worker, circadian disruptions may be as important.

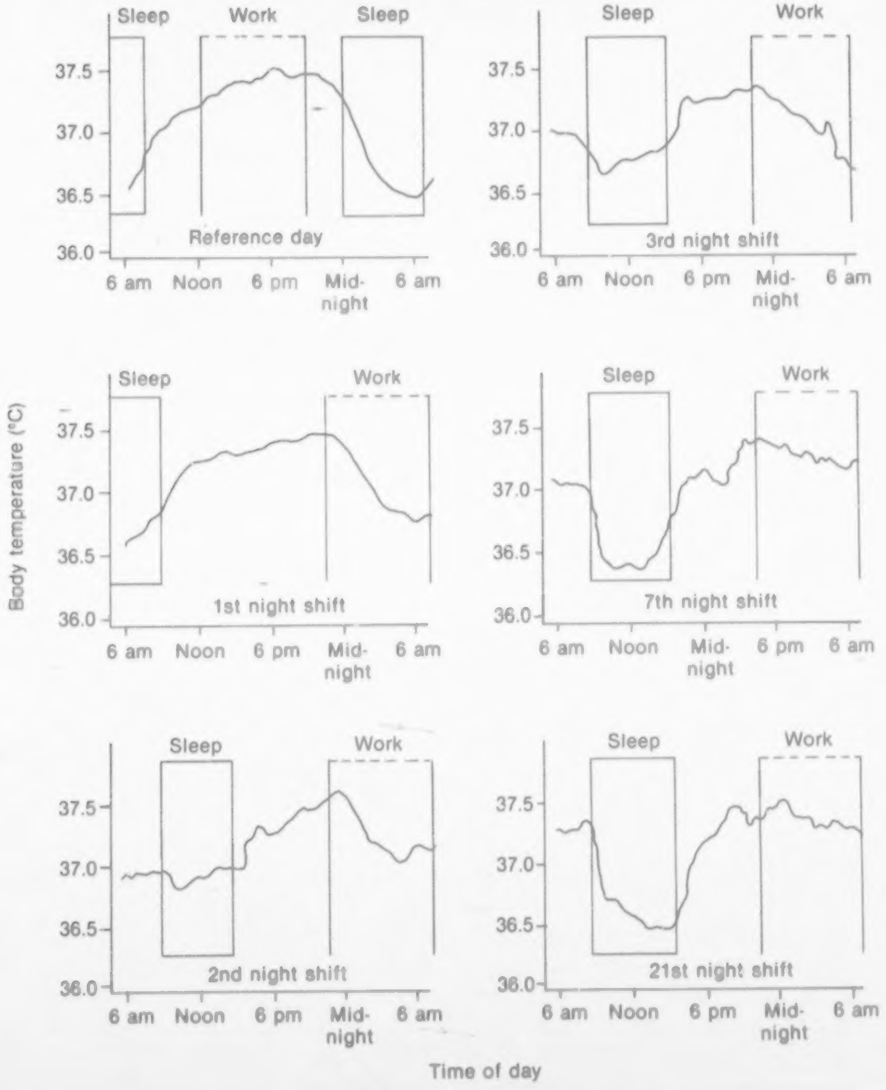
The impact of these stressors and their resultant consequences may, in some individuals and some situations, lead to difficulties in coping with the work schedule. **There is great variability among people in their ability to adjust to shift work, with some individuals suffering few, if any, problems and others finding certain work schedules intolerable.** It should be kept in mind, however, that even those individuals who appear to adjust well to shift work may experience negative effects on factors such as performance or safety. Also, for some individuals, some of the nonphysiological characteristics of shift work (e.g., improved access to daytime services, more time with young children, a sometimes lighter workload, higher pay) may be positive attributes. For others, the negative factors associated with shift work make adaptation difficult. In a study of 9,000 shift workers, it was found that 20 percent had difficulty adapting to shift work (140). This percentage rises as one moves to older age groups. In a study of an Austrian oil refinery, it was found that more than 80 percent of the sample expected to be unable to continue shift work until retirement (88).

Disruption of Circadian Rhythms

As previously mentioned, work schedules can have two consequences related to circadian rhythms. First, a schedule may require that an individual be awake and active at an inappropriate time during the circadian cycle. Second, work schedules can result in a state in which the individual's circadian rhythms are out of synchrony. As described in chapter 3, the circadian system is kept on track by an entrainment mechanism that uses time cues in the environment (light-dark) and the behavior of the individual (social interaction, meal times, sleep-wake schedule, and so on). This entrainment mechanism keeps an individual's circadian cycles aligned and in tune with the 24-hour rotation of the Earth. The process of adjustment to the abrupt, large changes in routine caused by shift work is slow, typically taking a week or more (82,108,175) (figure 5-1). Not only does the inherent inertia of the circadian system slow adaptation to a work schedule, the presence of competing time cues (e.g., light-dark, social cues) further slows the adjustment process.

Irregular work schedules (e.g., those routinely experienced by locomotive engineers) and schedules that involve frequent crossing of time zones (transmeridian airline crews) result in chronic circadian desynchronization. In rotating shift work, although the rotation schedule is fixed and regular, the length of time spent on a given shift may not be sufficient to allow for complete resynchronization of the circadian system. In weekly rotations, complete re-entrainment may never occur, and the worker may be in a perpetual state of circadian desynchronization (150). In a rapidly rotating schedule (1 to 3 days) shift changes occur so quickly that the circadian system does not have enough time to begin resynchronizing before the next rotation change; as a result, the worker's cycles remain diurnal (figure 5-2). However, the individual will be out of synchrony when he or she is working on the night shift. Some researchers (56,82) maintain that, regardless of rotation length, complete realignment of circadian cycles never actually takes place in shift work due to the competing influences of cues in the society telling workers that they are on an abnormal schedule. Even in permanent night shift work, if the worker does not maintain the same schedule on days

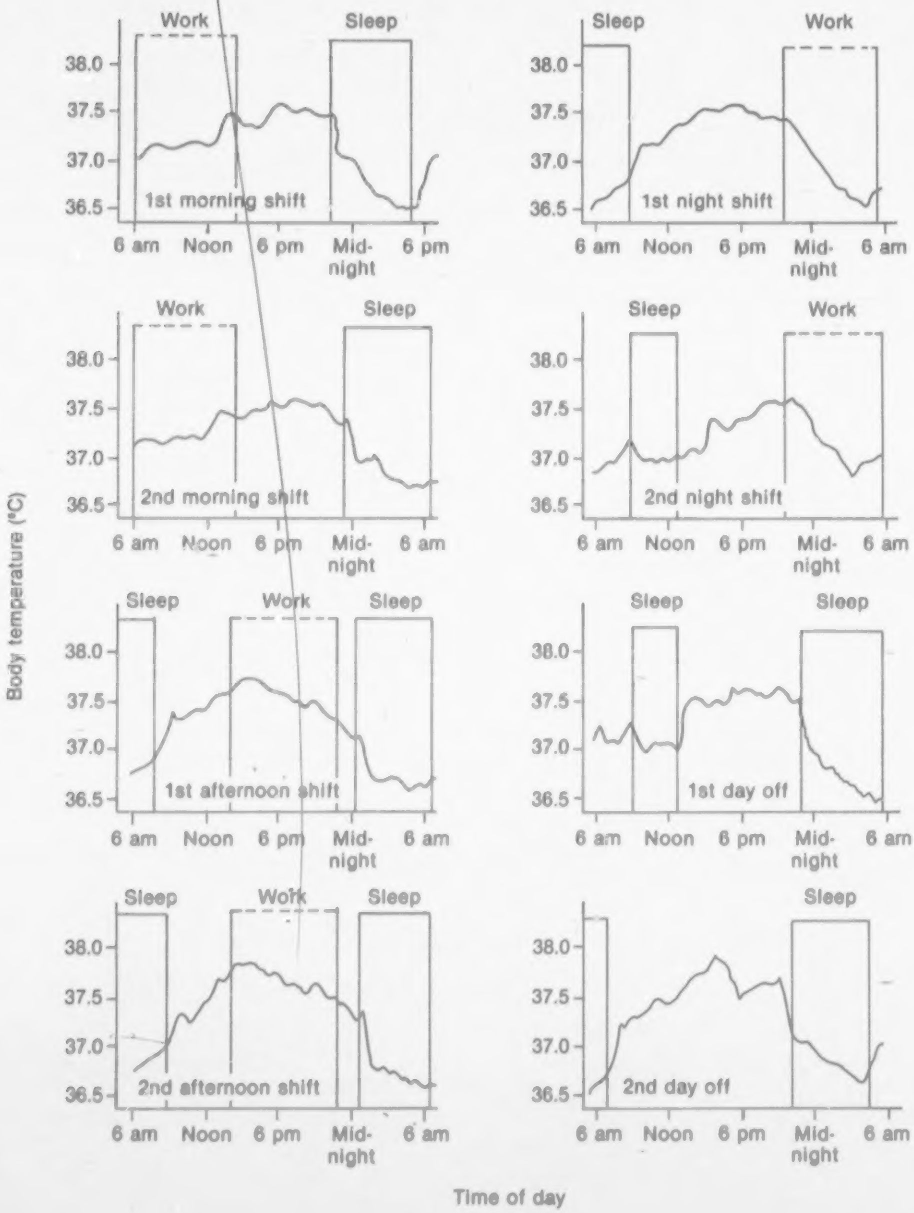
Figure 5-1—Relationship of Body Temperature, Work, and Sleep on a Permanent Night Shift



Graphs showing average body temperature of workers on the day preceding the start of night work and on days on the night shift. By the seventh night, body temperature has synchronized to the night schedule.

SOURCE: Adapted from S. Folkard, D.S. Minors, and J.M. Waterhouse, "Chronobiology and Shift Work: Current Issues and Trends," *Chronobiologia* 12:31-54, 1985.

Figure 5-2—Relationship of Body Temperature, Work, and Sleep in a Rapidly Rotating Schedule



Graphs showing average body temperature of four workers on a 2-2-2 rotating shift system. On the night shift, the low point of body temperature coincides with the work period.

SOURCE: S. Folkard, D.S. Minors, and J.M. Waterhouse, "Chronobiology and Shift Work: Current Issues and Trends," *Chronobiologia* 12:31-34, 1985.

off as on workdays, he or she will rapidly revert to the natural diurnal orientation (105,165). In such circumstances, the circadian system never fully synchronizes to the night schedule.

A desynchronized circadian system produces a number of effects on the individual. First, since the circadian system sets the time for sleep and wakefulness, a disrupted circadian system will interfere with both sleep and daytime functioning. Daytime sleep will be disrupted by daytime mechanisms, and the ability to stay awake at night will be impaired by circadian functions that are normally associated with sleeping (5,7,56). In some tasks, particularly monotonous ones such as driving, vigilance, monitoring, and quality control, this may lead to decrements in performance that compromise productivity and safety (42,57,108). Second, as discussed in chapter 3, the ability to perform certain types of tasks is also on a circadian cycle. A desynchronized circadian system results in the person's attempting to perform certain tasks at a time in the circadian cycle when his or her ability to perform those tasks is not optimal (56). Finally, an inappropriately synchronized circadian system is in a state of disharmony akin to that of a symphony orchestra without a conductor. The disharmony itself may result in feelings of malaise and fatigue, as well as certain gastrointestinal symptoms (37,140).

The degree to which individuals are affected by circadian disruption varies (132). There is often an interaction between aging and circadian rhythms, which would indicate a greater susceptibility to rhythm disturbances with age (see ch. 3) (80). These **factors suggest that some people may be better able to tolerate the circadian desynchronization associated with shift work than others.**

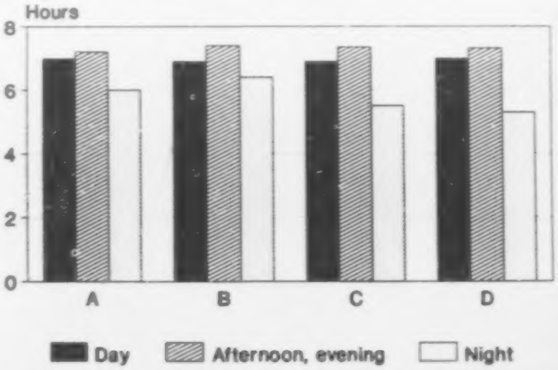
Sleep Disruption and Fatigue

Schedules that require work during nighttime hours are associated with sleepiness and fatigue. About 60 to 70 percent of workers on rotating shifts complain of sleep disruption (141), and general fatigue is reported more frequently by shift workers than by day workers (5). In a study of diverse occupational settings that included steel workers, meteorologists, and police, 80 to 90 percent of the subjects reported that they experienced fatigue during night work (6). Sleepiness is generally associated more with the night shift than the morning and afternoon shifts. The most common complaint is the inability to sleep as long as necessary during the day (2). Permanent night workers also have shortened sleep, although to a lesser extent than rotating shift workers (38,172) (figure 5-3). Sleep disturbances and fatigue can occur as a result of the irregular hours typically worked by railroad engineers (154,159), the work schedules and jet lag experienced by commercial airline pilots (64,67), the watch schedules aboard merchant ships (142), and the extended on-call schedules of resident physicians in hospitals. Any job involving long work periods, whether as a result of overtime or as part of the regular schedule, can result in sleep loss and fatigue (box 5-A).

A worker's sleep can be disrupted by both endogenous and exogenous factors. As mentioned earlier, the endogenous factors stem from the desynchronized circadian system, which has failed to prepare the body and mind for sleep and wakes the system up before 7 or 8 hours of restful sleep have been obtained (5,56). Often, workers will complain of being wakened by exogenous factors (e.g., traffic noise, children playing), whereas in reality it is their desynchronized circadian system that is the culprit (4,59). Workers will also experience fatigue and sleep loss from any work schedule that requires them to stay up for long hours.

Exogenous factors can be just as big a problem. The daytime environment is much less conducive to sleep than the nighttime. Daylight can intrude on

Figure 5-3—Length of Sleep of Permanent and Rotating Shift Workers



Average sleep lengths on different shifts for two samples of permanent (A,B) and rotating (C,D) shift workers. Rotating shift workers on the night shift had the shortest average sleep lengths.

SOURCE: M. Colligan and D. Tepas, "The Stress of Hours of Work," *American Industrial Hygiene Association Journal* 47:686-695, 1986.

Box 5-A—Night Shift Paralysis

One consequence of sleep deprivation is the occurrence of a rare phenomenon known as night shift paralysis. This condition is marked by a momentary paralysis, usually lasting about 2 minutes, during which individuals are aware of their surroundings but are unable to make voluntary movements. Night shift paralysis has been observed in studies of nurses, naval officers, printers, and air traffic controllers and is associated with high levels of sleepiness.

In a study that looked at night shift paralysis in 435 air traffic controllers from 17 countries, 26 claimed to have experienced night shift paralysis at some time during their careers. A total of 75 incidents was reported by these 26 controllers. The researchers conducting the study calculated that the potential for an accident resulting from an occurrence of this paralysis is 0.5 time in each individual's working life. No accidents or near misses were associated with any of the episodes of night shift paralysis reported in this study.

Factors identified as contributing to the occurrence of night shift paralysis include time of night, the number of consecutive night shifts the person had worked, and having worked both a morning and a night shift on the same day. Of the 75 reported incidents, 56 took place during the night shift, 12 during the day shift, and 7 during the morning shift. Interestingly, it was observed that individuals who were more rigid in their sleeping habits were more likely to experience night shift paralysis than persons who were able to fall asleep at unusual times. This seemingly paradoxical finding may be due to the fact that flexible sleepers may suffer less sleep deprivation when working shifts (see text).

The researchers concluded that the incidence of night shift paralysis may be a useful reflection of the extent of sleep deprivation. They also suggested that its occurrence may be reduced by limiting the number of successive night shifts to one and by not allowing an individual to work both a morning and a night shift on the same day. Thus, while night shift paralysis is an extremely uncommon event, it does illustrate how work schedules can cause sleep deprivation, with potentially far-reaching effects.

SOURCE: S. Folkard and R. Condon, "Night Shift Paralysis in Air Traffic Control Officers." *Ergonomics* 30:1353-1363, 1987.

sleep if the sleeping quarters are not sufficiently darkened. Households are noisier, and there is a much greater chance of interruption from telephones ringing, televisions playing, and general activity both inside and outside the home. In addition, the worker may feel compelled to interrupt sleep voluntarily in order to meet family and social demands that occur during the day (101,153). Consequently, day sleep is much more susceptible to disruption by domestic commitments (shopping, child care, and so on) than is night sleep. Very often, social and domestic disharmonies (see later discussion) tend to develop because family members get blamed for sleep disruptions that may not be entirely their fault. In addition, if a shift worker takes on another job, the likelihood that he or she will set aside adequate time for sleep diminishes further.

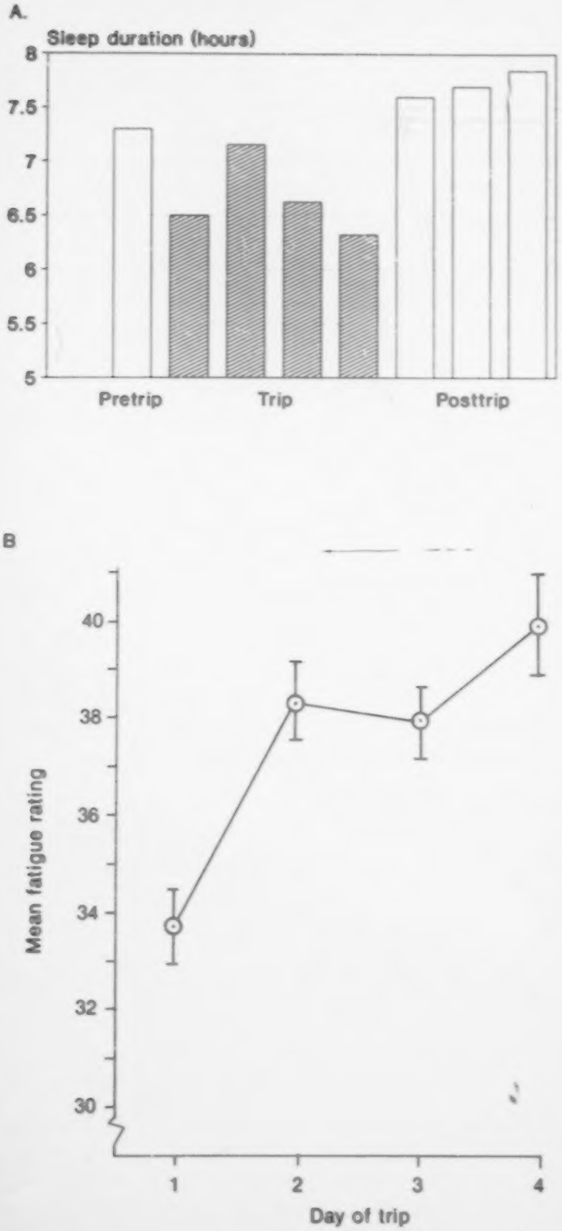
The net effect of these sleep disruptions is lack of sufficient sleep, which often results in a state of chronic fatigue and sleepiness referred to as sleep debt (5). This is especially true for rotating shift workers while they are on the night shift, permanent night workers, and individuals who are routinely subjected to long and irregular hours of work that extend into the night. For rotating shift workers, there may be some respite while they are on the morning or afternoon shifts, but depending on the design of the schedule, the degree to which they recoup the sleep lost during the night shift will vary. Sleep debt has important implications for worker performance, safety, and health (figure 5-4).

Individuals vary in their ability to sleep. Some people are more rigid in their sleep habits and have trouble sleeping at unusual times, while others seem to be more flexible in their ability to sleep at odd times. Some evidence suggests that people who find it easier to sleep at odd times may have an easier adjustment to the disruptions in sleep that can occur from work schedules (33,57).

Social and Domestic Disturbances

Work schedules may induce stress by preventing the worker from fulfilling important family roles (167). Social companionship, parenting, and sexual partner roles can all be compromised by work schedules. These effects may be major and can severely affect mood, motivation, and sleep, therefore having indirect effects on performance and safety. Marital problems, excessive domestic load, and community alienation have all been documented as a result of the strain placed on workers by work

Figure 5-4—Sleep Duration and Fatigue in Aircrews During a 4-Day Trip



A) Self-reported sleep duration of aircrews on a 4-day trip and the days preceding and following the trip. B) Subjective ratings of fatigue during the trip.

SOURCE: Adapted from R.C. Graeber, "Aircrew Fatigue and Circadian Rhythms," *Human Factors in Aviation*, E.I. Weiner and D.C. Nagel (eds.) (San Diego, CA: Academic Press, 1988).

schedules. A survey of 1,028 married couples in the United States found that shift work is associated with lower-quality family time and more frequent family conflicts (148). Another study found that shift work increased the probability of divorce from 7 to 11 percent over the 3-year period of the study (178). A more dramatic effect was reported in a study of 1,490 workers (152) in which an almost 50 percent increase in divorce and separations was found among those on fixed night shifts compared to morning and evening shifts. When asked whether they were satisfied with the amount of time they had available to spend with family and friends, workers on night or evening shifts were about half as likely to respond "yes" as their morning shift colleagues. Similar findings come from Europe and Scandinavia. In a 15-year study of 504 Swedish paper mill workers (87), the divorce rate among shift workers was double that of day workers.

Excessive domestic workload represents a major source of stress from shift work for women workers. Married women are often expected by their husbands to continue to run the household, raise the children, and do domestic chores; shift work can compound this burden (63). For these women there is usually insufficient free time available for household duties, and time is therefore borrowed from sleep. It has been observed that female night workers with two children slept about 9 hours less per week than their unmarried female colleagues (63).

With the increase in dual-income families, a more common mode of arranging child care is for spouses to work different shifts (113,125). This splitting of child-care responsibilities between two working individuals also extends to nonspouse care givers. A study showed that one-third of grandmothers who provide child care for their grandchildren, and who are employed, work a different shift than the children's mothers (126).

Finally, social problems are encountered by shift workers. Society is geared toward a Monday to Friday, daytime work schedule. Several researchers (167) have found that shift workers may feel alienated from the community because they are unable to attend evening educational, sports, or religious meetings or weekend recreational events. Team or club membership becomes difficult because of irregular attendance, and few shift workers hold office in clubs and societies. The shift worker can feel left out of community benefits and opportuni-

DAY SLEEPER
243

Photo credit: David Liskowsky

Obtaining adequate sleep during the day is often difficult for the shift worker.

ties. Such effects are much less frequent in company towns, where shift work is the rule rather than the exception, and as a consequence nonstandard work schedules are considerably better tolerated (174).

CONSEQUENCES OF WORK-RELATED STRESSORS

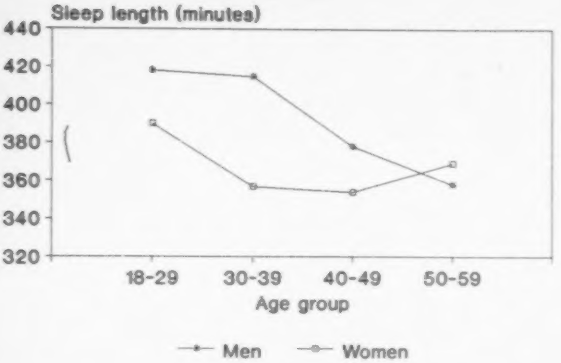
The three stressors previously described (circadian rhythm disruption, sleep disruption, social and domestic disturbances) can combine to cause a variety of problems for the worker. **The degree to which a person suffers from the consequences of work-related stressors varies greatly among individuals.** At the present time, not enough is known to make a definite statement about who will or will not be able to cope with shift work. As was mentioned earlier, the ability of a person to adjust to circadian disruption and sleep disturbances may affect his or her ability to tolerate the demands caused by work schedules. For example, circadian rhythm patterns are not the same in all people. Some people have consistently longer free-running periods and a wider amplitude between their maximum and minimum daily body temperatures. Evidence suggests that these individuals are better able to tolerate shift work than persons with naturally shorter free-running periods and a narrower body temperature range (20,129,130,131). However, it is not clear if these characteristics are a benefit in all shift work schedules.

Other characteristics related to sleep habits and personality have been combined to divide people into two categories. It has been hypothesized that these categories may have some validity in predicting success in coping with work schedules. A morning person is someone who gets up easily and is active in the morning, has a hard time sleeping late, and falls asleep quickly in the evening. In contrast, an evening person is more alert at night, able to sleep late in the morning, and takes a long time to fall asleep at night. It is thought that the evening person is more adaptable to varying work schedules (106,110,120). Additional information is needed to test the validity of this hypothesis and to identify more clearly variables that might make some individuals better able to cope with changing work schedules than others.

Another important factor in determining who will cope best with shift work is age. As one ages, the internal clock and sleep patterns change (figure 5-5). The internal clock may become harder to reset with age, and sleep becomes more fragile and easily disrupted. These effects usually begin to occur after the age of 45. For example, a survey of rotating shift workers found that older workers (45 to 60 years old) had more difficulty adjusting to night and afternoon shifts than did younger workers (79). It is not uncommon for a person who has been working shifts all of his or her career without undue strain to start having trouble coping as he or she gets older. A variety of health problems can appear with age and can add to the difficulty of coping with shift work (109).

While these factors suggest who might be best suited for shift work, the combined effects of these and other factors (e.g., physical ailments, family and social status) increase the variability of individuals' ability to cope with shift work (90). As a result, for some people, shift work is only an

Figure 5-5—Length of Sleep of Permanent Night Shift Workers



Graphs showing the average sleep length for male and female permanent night shift workers, according to age.

SOURCE: D. Tepas, Department of Psychology, University of Connecticut, 1990.

inconvenience, while for others it can have major consequences. It has been estimated that about 20 to 30 percent of shift workers actively dislike their schedule (56). Often, workers who find they cannot adjust to the demands of shift work change to day jobs. Thus, there is a strong self-selection process in operation that has important implications for studies of the effects of work schedules. The populations being studied may represent individuals who are indifferent to or who can tolerate the negative consequences of shift work, and thus the studies may underestimate the true effects of nonstandard schedules (111).

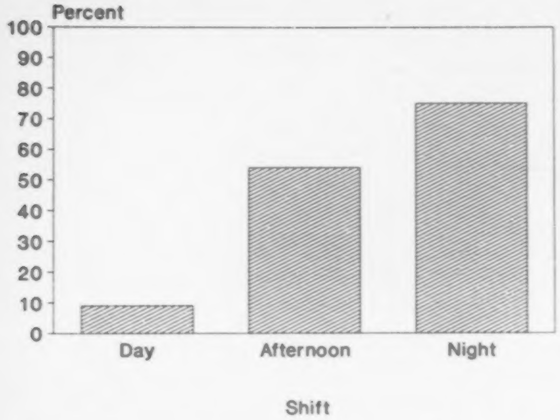
Health

The stressors described in the previous section may interact to have negative effects on the health of a worker. In general, these effects result from chronic, repeated exposure to stressors, for example, the continuing circadian desynchronization that rotating shift workers experience or the constant stress placed on night workers to meet family and social obligations during the day. Surveys have shown that shift workers, particularly those on rotating shifts, have a higher incidence of sick leave, a higher rate of visits to clinics at the work site, and poorer scores on a variety of indexes of health (111,112). Thus it appears that a greater proportion of shift workers than day workers suffer general health complaints. For example, a study of policemen found that those working rotating shifts reported a higher incidence of complaints of muscle aches, respiratory infections, and gastric complaints than did officers working days (123). In addition to general health complaints, there is some relationship between shift work schedules and the occurrence of specific disorders, primarily gastrointestinal problems.

Shift workers, particularly those on night shifts, commonly complain of gastrointestinal disorders (94,111), including general gastric discomfort and peptic ulcer disease (15,37,111,140). One study comparing the incidence of peptic disease in night workers and in day workers showed that the two groups begin to differ only after 5 years of exposure to their respective work schedules (10). There are probably several reasons for the higher incidence of gastrointestinal complaints among night workers. Intestinal enzymes are secreted in a circadian cycle that is disrupted by night or shift work schedules, contributing to digestive distress. Also, the link between meal patterns and the circadian system, which has to suspend appetite and voiding in order to allow 7 or 8 hours of uninterrupted sleep, may play a role. For example, the eating habits of shift workers tend to be irregular, with workers not adjusting their meal schedules to match their work schedules (47,56,72,120). It is also often difficult to obtain high-quality meals at odd hours (56) (figure 5-6). The link between eating habits and gastrointestinal complaints in shift workers indicates an area in which employee education might play a useful role. Risk factors associated with gastrointestinal disorders, such as increased alcohol and tobacco consumption, have also been shown to be higher in shift workers than in day workers (10,149). Finally, the psychological stress associated with family disharmony or social disruption could contribute to gastrointestinal problems.

Another major medical concern is cardiovascular disease; however, the link between it and shift work is not as strong as that for gastrointestinal problems. While some earlier reviews of the field did not find compelling evidence of a link (72,140), more recent research from Sweden (87) has demonstrated that shift work is associated both with increased risk of cardiovascular disease and with its associated risk factors (122). A study of Akron police officers showed that rotating shift work may be associated with high levels of norepinephrine (a body chemical that causes an increase in heart rate and blood

Figure 5-6—Shifts Interfering With Eating Habits



The percentage of coal miners reporting that a given shift interfered with their eating habits.

SOURCE: J.C. Duchon and C.M. Keran, "Relationship Among Shiftworker Eating Habits, Eating Satisfaction, and Self-Reported Health in a Population of Miners," *Journal of Work and Stress* 4:111-120, 1990.

pressure), which could place workers at higher risk of cardiovascular problems (54). A recent review of the literature related to cardiovascular disease and the work environment concluded that ". . . the better studies in the field consistently find a modestly higher incidence of cardiovascular disease among shift workers" (89).

Finally, a few studies present data suggesting a slightly increased risk of miscarriage, preterm birth, and lower birth weight among women who work rotating shifts or irregular hours (12,14). A study of complications during pregnancy and adverse outcomes of pregnancy found no link to shift work, but it did note an association between shift work and a tendency for babies to be smaller for their gestational age (119).

Beyond these specific disorders, the adverse effects of shift work on workers' health seem to be diffuse, affecting some workers' general sense of well-being. These workers frequently report sleep disturbances and fatigue, menstrual problems, increased feelings of irritation and strain, increased use of alcohol and other drugs (tranquilizers, caffeine), and a general feeling of malaise that may be exacerbated by psychological stress related to being less satisfied in the domestic and social areas of their lives (65,112). It has also been proposed that the stresses associated with shift work might exacerbate preexisting health conditions, increasing their severity without increasing their incidence (29).

A related health problem may be the inability of the shift worker to comply with health and medication regimens. As discussed in chapter 3, the body's metabolism and response to drugs are generally circadian. Also, symptoms of some disorders, such as diabetes, depression, and asthma, evidence significant circadian fluctuations. A shift worker could be in the position of taking medication at inappropriate or constantly changing times. Also, variable work schedules could make it difficult to coordinate taking medication with the work-rest cycle and mealtimes, thus interfering with the worker's ability to take medication at all (29).

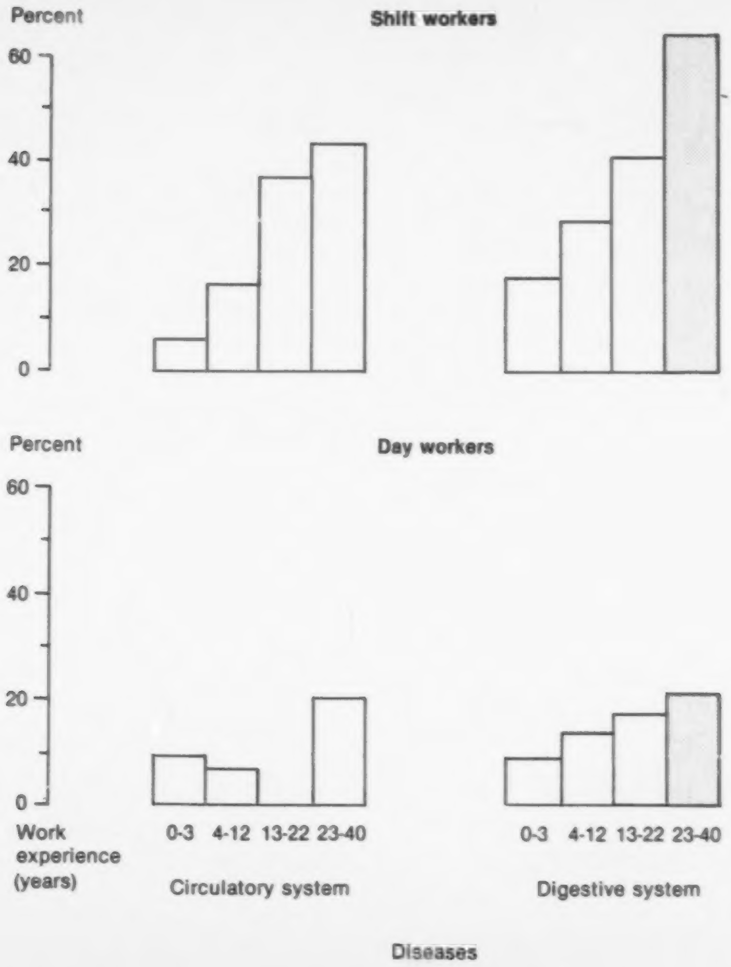
In summary, shift work schedules are associated with increased gastrointestinal complaints among workers and may be a risk factor in cardiovascular disease and such pregnancy outcomes as low birth weight and preterm births (figure 5-7). Beyond these specific ailments, the health effects of such work schedules generally manifest themselves as complaints of decreased well-being, chronic malaise, and poor sleep. Shift maladaptation syndrome is the term used to describe the effects of long-term shift work on the health of workers who have never been able to adjust to it.

Performance

The effects of work schedules on performance are part of a complex set of factors that shape a person's performance in a given situation. These factors include the circadian, sleep and fatigue, and social and domestic stressors already described. They also include the type of task to be performed (e.g., vigilance, physical, cognitive), motivational effects (which are significantly influenced by social and family concerns), the work schedule being employed, and individual differences among workers (e.g., personality, age, health, sleep needs, behavior patterns) and how they adjust to changes in routine. Unlike health effects, performance decrements may occur soon after exposure to a work schedule.

As discussed in chapter 3, performance on a number of different types of tasks displays a circadian rhythm, and different types of performance differ in their normal phase and the degree to which they are affected by outside influences. For example, tasks involving signal detection, reaction time, and handling of simple arithmetic correlate with cir-

Figure 5-7—Prevalence of Disease in Shift Workers and Day Workers



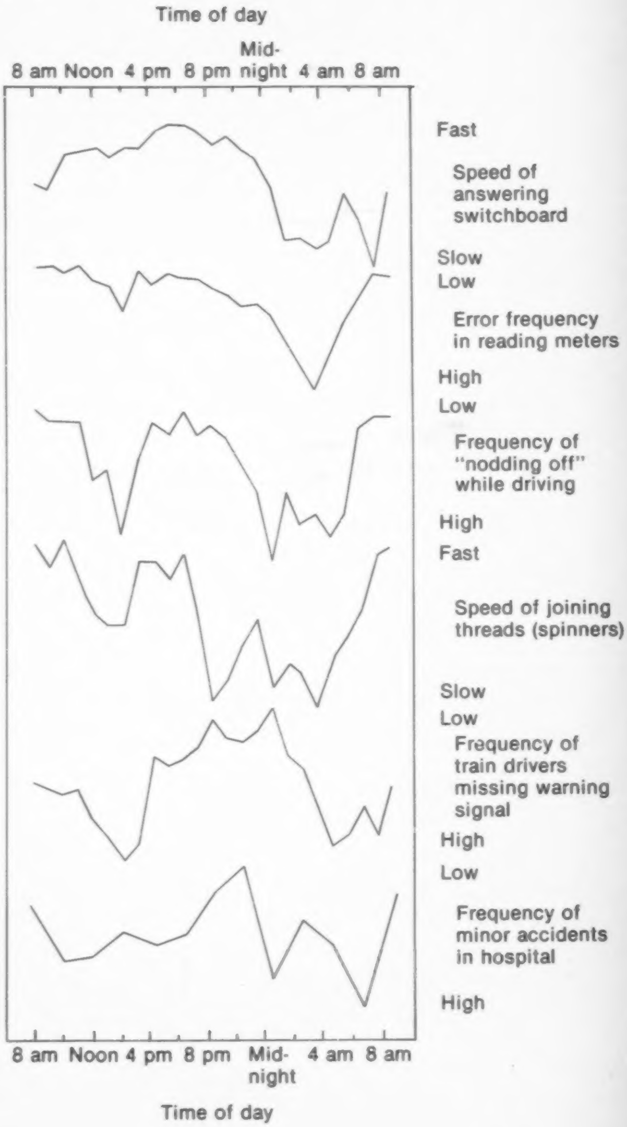
Percent of shift workers and day workers at an oil refinery, subdivided into groups according to work experience, suffering from circulatory and digestive diseases. Shaded bar indicates that there was a statistically significant difference between the shift workers and day workers.

SOURCE: Adapted from M. Koller, "Health Risks Related to Shift Work: An Example of Time Contingent Effects of Long-Term Stress," *International Archives of Occupational and Environmental Health* 53:59-75, 1983.

cadian changes in body temperature, peaking during the afternoon, while performance of cognitive tasks involving memory may peak in the morning (28,56). Performance can be directly affected by circadian desynchronization and inappropriately timed activity, as well as by the loss of sleep they can cause. There is a large body of literature regarding the effects of fatigue and sleep deprivation on performance; these factors clearly have a negative effect on the performance of most tasks (28,91).

In contrast to the fairly extensive research on the circadian component of performance and the effects of sleep deprivation on performance, much less research has been done on the complex interaction of variables that occurs in a work setting that can also affect worker performance. To determine the effects of work schedules on performance, studies can examine the performance of a worker either on a standardized test battery after being exposed to a certain work schedule or on the actual task the job involves. A factor that can complicate the study of intershift differences in task performance and perhaps mask the effects of shift work is the difference in working environments. Not only environmental conditions, such as lighting levels, but also supervision levels, group morale, and distractions can all vary between night shifts and day shifts. Also, poorer performance can occur on the night shift simply because no one is available to repair broken machines (102). The work itself may be quite different on the night shift. Very often, certain parts of the job are saved for the night shift, either because the process demands it (preparing things for shipment in the morning) or because it places less demand on the night workers. In continuous-process operations, complicated development work may intrude during the day but not at night (40).

Figure 5-8—Work Performance in Various Job Settings



Variations in measures of on-the-job performance, by time of day, from a variety of studies.

SOURCE: Adapted from T.H. Monk, "Shiftworker Performance," *Shiftwork, Occupational Medicine State-of-the-Art Reviews*, A.J. Scott (ed.)(Philadelphia, PA: Hanley & Belfus, 1990).

The relatively few studies that have recorded 24-hour real-task data in the field demonstrate decreased performance at night. They have shown that the speed at which a task can be performed decreases at night (21,182) and the probability of making an error, missing a warning signal, or nodding off while driving is highest at night (17,58,75,127) (figure 5-8). In addition, some evidence shows a pronounced postlunch dip in these measures. More recent studies have found the risk of accidents involving truck drivers between midnight and 2 a.m. to be more than double the average during the day (69). Job performance of nurses, as measured by a questionnaire filled out by supervisors, was found to be lower in those on a rotating shift than in those on fixed day, afternoon, or night shifts (27).

Studies using other measures of performance have also found effects related to work schedules. For example, results of a study that measured manual dexterity and search performance of 10 factory workers on a rotating shift showed the workers performed worst on the tests when working the night shift (181). The tests were administered just before the start of a shift and after 4 and 8 hours of work. Another study brought shift workers into the laboratory during nonwork hours for performance testing and measures of brain activity during sleep. These workers continued to work at their normal workplace, but they commuted to and from the laboratory rather than home (155,156). Their performance on a vigilance task was examined just before bedtime, at bedtime, and on awakening. The study involved 10 night workers, 10 day workers, and 10 (slowly) rotating shift workers who were working day or evening shifts at the time they were tested. Night shift workers performed worst on all three performance tests, but there were no reliable differences between the other two groups. The differences in performance were not accompanied by equivalent differences in body temperature, but they were correlated with brain activity during sleep in a way that is typical of subjects undergoing chronic partial sleep deprivation.

Similar results were obtained when 12 shift workers were studied for one complete cycle of their weekly rotating shift in the field rather than in the laboratory (158). Reaction speeds on both a simple and a complex reaction-time test were slower among workers on the night shift. There was also strong evidence of an increasing deterioration in performance, which the authors interpreted as a buildup of partial sleep deprivation. The effects on a number of different measures of performance of the 4-hours-on, 8-hours-off schedule typically used on merchant ships for standing watch has also been examined (32). There was only a partial adaptation of circadian rhythms to this schedule, and most performance measures showed lower values during the night hours. The decrements in performance were exacerbated by disturbances in sleep that occurred as a result of the split hours of sleep time necessitated by this schedule. These studies demonstrate some of the effects that disrupted circadian rhythms can have on performance and their interaction with other factors involved in shift work, notably sleep deprivation.

The studies described above examine the effects on performance of work schedules involving rotating shifts or night shifts. **Jobs that require sustained or extended duty hours can also affect performance.** For example, jobs such as cross-country truck driving require long hours of constant attention, often in a boring or repetitive environment, while jobs such as those of residents in hospitals involve continuous work, interrupted by periods of reduced activity or rest breaks. While circadian disruption plays a role in the performance decrements observed under these conditions, sleep loss is probably an equally salient factor (91).

A laboratory study that required subjects to perform 54 hours of continuous work found that reaction time, logical reasoning, vigilance, and encoding and decoding messages all declined in a stepwise fashion; that is, declines in performance were interspersed with plateaus in performance (11). The declines in performance were paralleled by subjective ratings of fatigue and sleepiness; the greatest declines occurred in conjunction with the lowest point in the circadian cycle of body temperature. Similar results have been described when a computerized test battery was used to measure performance (115). While these studies show that decrements in performance can occur as a result of extended duty hours, a number of other studies found that certain kinds of performance are more sensitive to sustained operations than others (91). In general, these studies found that psychological tasks, such as cognitive, vigilance, long-term memory, decisionmaking, and perceptual-motor tasks, were more likely to be adversely affected by sustained operations than were physical tasks involving gross motor activity and strength.

Thus it is reasonable to assert that, in general, shift work decreases performance and that a number of factors besides circadian desynchronization contribute to this decrease, notably sleep deprivation and fatigue. A great deal more information still needs to be derived, however. As with health effects, there is a complex interaction of factors that under actual working conditions could contribute to or counteract decrements in performance (namely, nature of the task, speed at which the task is performed, work schedule employed, worker age, family and social factors, motivation). More information is needed to delineate the effects of these interacting factors in a given work situation. A better understanding of how performance on different types of tasks can be affected will make it possible to devise interventions and countermeasures.

Safety

The factors described earlier also have an impact on worker safety. Performance decrements resulting from sleepiness, circadian disruption, or distraction by family problems can cause situations that might compromise the safety of the individual and, depending on the nature of the job, public safety as well.

In the United States, the major mechanism for collecting data related to workplace injuries and mishaps is the Bureau of Labor Statistics (BLS) in the Department of Labor. Currently, BLS forms for reportable injuries and illnesses include no questions regarding the time of day an incident occurred, the type of schedule an employee involved in an incident was working, the number of hours since the employee began work, or the total number of hours or shifts the employee had worked over the preceding days. **Thus, data currently being gathered by the BLS provide no information that could facilitate an assessment of the impact of shift work on employee safety and health.** The Occupational Safety and Health Administration, within the Department of Labor, may record information on time of day and hours of work when investigating workplace fatalities and catastrophic incidents in which five or more persons are injured or substantial property damage is caused.

Data on injuries can be put to three possible uses. First, they can be used to investigate whether the work environment or supervisory practices were different on a particular shift and to see if schedule changes had any effect on injury rate. Second, they can be used for research examining features of the work environment and schedules that are related to injury rates. Finally, the data can be used in providing surveillance of the workplace.

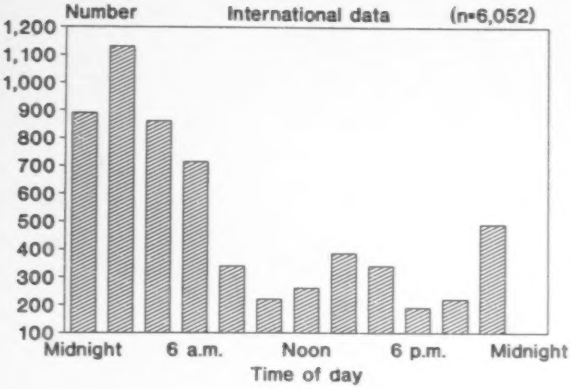
Another source of data is the National Transportation Safety Board (NTSB), which investigates transportation-related mishaps. In its investigations the NTSB routinely collects information regarding the role work hours might play in such incidents. Other Federal agencies and departments (e.g., the Nuclear Regulatory Commission or the Department of Transportation) may examine the role of work hours when investigating incidents that occur within their domain. For example, the U.S. Army, as part of its Army Safety Management Information System, maintains a database regarding Army aircraft accidents involving a death or loss of an aircraft (55). This database includes information related to sleep and work periods. To date, no analysis of these data has been performed to determine the role of duty hours in these incidents.

Other sources of information related to work schedules and their implications for worker safety include surveys of specific industries or work sites and data from other countries. As described earlier, studies of the effects of work hours are often confounded by the fact that in some settings the conditions surrounding night work are quite different from those surrounding day work. This is particularly true of industrial or manufacturing settings.

While it is possible that the performance decrements that occur in shift work will translate into an increased rate of mishaps and injuries in the workplace, the published data in this area are meager. Some studies in industrial settings have not found an increase in injuries related to night shifts or shift work [injuries at a chemical plant (118), U.S. coal miners (173), survey of industrial accidents in New Zealand (49)], while others found that, although injury rates were higher during the day, the severity of the injuries suffered at night was greater [iron and steel mill workers in Singapore (121), U.S. iron miners (166)]. On the other hand, a survey of occupational mishaps in a glass factory and a steel factory and data on occupational mishaps occurring in Ontario over a 5-year period found that the number of occurrences peaked just before and after lunch, as well as between 2 a.m. and 4 a.m. (180). A survey of a paint factory in the United States found that the injury rate was 25 percent higher for night shift workers than for day shift workers (95). It was also noted that this effect was most pronounced in the last 3 hours of the night shift. Thus, there is some indication that shift work can result in decreased safety in an industrial setting; however, there is no complete characterization of the types of settings most likely to be affected. **Until there are more data on the relationship between work hours and workplace mishaps, the extent to which mishaps are caused by shift work will remain uncertain and the development of interventions to counteract them will be hindered.**

In contrast, examination of factors contributing to transportation mishaps shows the role of circadian disruption, sleep loss, and fatigue (figure 5-9). These three factors have been noted in specific incidents involving every mode of transportation, including airline, railroad, maritime, and highway driving (93). Studies have shown that the risk of a truck driver's being involved in a traffic collision is higher for trips occurring at night. One study identified the period between midnight and 4 a.m. as the most dangerous, with the peak being between midnight and 2 a.m. (69), while another identified the period between 4 a.m. and 6 a.m. as the most crucial (100). The chances of an accident were increased further if the driver had been on the road or working for an extended period of time (69), and the effects of sleepiness and fatigue were compounded if the

Figure 5-9—Fatigue-Related Vehicular Accidents



The distribution, by time of day, of 6,052 vehicular accidents that were judged by investigators to be fatigue-related.

SOURCE: M.M. Mittler, M.A. Carskadon, C.A. Czeisler, et al., "Catastrophes, Sleep, and Public Policy: Consensus Report," *Sleep* 11:100-109, 1988.

driver was on an irregular schedule (100). A recent study by the NTSB highlighted the role of combined sleep loss and fatigue and its interaction with drug use in a study of fatal-to-the-driver heavy truck crashes in the United States (117). The report found that sleep loss and fatigue was the most frequently cited single cause or factor in the fatal crashes examined and that many of the drivers involved in these incidents were also impaired by alcohol or other drugs. Another study of crashes involving large trucks in the United States found that the "relative risk of crash involvement for drivers whose reported driving time exceeded 8 hours was almost twice that for drivers who had driven fewer hours" (76). Similar results were found in a study of naval pilots who were involved in serious mishaps (destroyed aircraft, fatalities) during a 5-year period (19). Pilots who had worked at least 10 hours before a mishap were more likely to have been at fault than pilots who had worked less than 10 hours. Also, the mishap rate was significantly related to time of day, with pilots having a lower rate of incidents during daytime hours.

Safety consequences of shift work can affect not only the worker, but also the public. They have been listed as contributing to such highly publicized incidents as the Three Mile Island nuclear powerplant accident and the grounding of the *Exxon Valdez* (box 5-B). In these incidents, the strain of extended duty hours and the time of day may have led to errors in attention, decisionmaking, and response to pertinent information. Events such as these can threaten thousands of lives and seriously affect the well-being of surrounding communities. At the other end of the spectrum are less publicized but more common examples of threats to public safety, such as accidents involving interstate truckers. Any occupation involved with public safety and welfare can be influenced by the effects of work schedules and their attendant problems. Decrements in performance among police, fire, and health care personnel could result in negative outcomes for the public. **Additional data on the occurrence of incidents threatening the public safety are needed to derive a clearer understanding of their frequency, nature, and magnitude. Such information can serve as the basis for preventive measures.**

INTERVENTIONS

The previous sections have described the consequences and impact shift work can have in a variety of realms. This section describes some interventions that may be used to lessen those effects. While a number of different interventions are being examined as possible means to counteract circadian desynchronization, sleep disturbances, and social disruption associated with work schedules, definitive statements regarding their effectiveness cannot be made yet. Additional research is needed on the mechanisms at work in specific situations and on the effectiveness of these interventions.

Work Schedules

Since a number of possible negative consequences are associated with shift work, an obvious approach to prevention is to avoid the use of such schedules. However, around-the-clock operations are a fact of life in many occupations, so the best intervention regarding scheduling is to identify those schedules that will have the least unfavorable impact on the individual. Making such a determination is difficult, because a schedule that may be the most beneficial from a circadian perspective may not be optimal in terms of sleep and fatigue, or a schedule that tries to avoid sleep loss may create hardships for the worker in the social or domestic arena. Also, the nature of the job and the type of performance it requires may make a schedule suitable for one type of task but not suitable for another. As stated by one researcher, "... the effects

Box 5-B—The Grounding of the Exxon Valdez

At about midnight on the morning of March 24, 1989, the tanker *Exxon Valdez*, loaded with almost 1.3 million barrels of crude oil, ran aground on Bligh Reef in Prince William Sound, Alaska. Approximately 258,000 barrels of oil spilled, resulting in severe damage to the environment. Damage to the vessel was put at $25 million, and the cost of the cleanup during 1989 was $1.85 billion. In the opinion of the National Transportation Safety Board (NTSB), which investigated this incident, the probable causes for the grounding of the tanker were:

- the failure of the third mate to properly maneuver the vessel because of fatigue and excessive workload;
- the failure of the master to provide a proper navigation watch because of impairment from alcohol;
- the failure of the Exxon Shipping Co. to provide a fit master and a sufficiently rested crew for the *Exxon Valdez*;
- the lack of an effective vessel traffic service because of inadequate equipment and manning levels, inadequate personnel training, and deficient management oversight; and
- the lack of effective piloting services.

This incident is an example of a situation in which negative work schedule effects combined with other factors to bring about an event that had broad implications for the public well-being. Prominent among the NTSB findings were a number that concerned the policies of Exxon Shipping related to the manning of its tankers. The NTSB found that these policies created conditions that were conducive to fatigue among tanker crews. In the case of the *Exxon Valdez*, the result was that there were no rested deck officers available to stand watch while the ship sailed through Prince William Sound, and the ability of the third mate to conn the vessel was impaired by fatigue.

Among the NTSB's recommendations related to work hours were that Exxon Shipping and other oil shipping companies eliminate personnel policies that encourage employees to work long hours and implement manning policies that prevent long working hours. Also, the NTSB recommended that shipping companies forbid deck officers to combine both navigation and cargo watch duties using a schedule of 6 hours on, 6 hours off. The NTSB recommended that the U.S. Coast Guard develop means to enforce the rule that officers on watch during departures from port must be sufficiently rested; that it expedite study programs to establish manning levels and safeguards to use in the manning review process; and that it establish manning standards that will ensure crews are large enough to handle heavy workloads. Finally, the NTSB reiterated previous safety recommendations to the Department of Transportation that it expedite research programs to study the effects of fatigue, sleep loss, and circadian factors on transportation system safety; that it disseminate information and educational material to transportation industry personnel regarding these effects; and that it review and upgrade hours of service regulations in all transportation modes to ensure that they reflect the latest research on these factors.

Photo credit: W.R. Woody, National Transportation Safety Board

The *Exxon Valdez*.

SOURCE: National Transportation Safety Board, Marine Accident Report, *Grounding of the Exxon Valdez on Bligh Reef, Prince William Sound, AK, Mar. 24, 1989*, NTSB/MAR-90/04 (Springfield, VA: National Technical Information Service, 1990).

of any particular work schedule are likely to be myriad and complex, potentially exerting a differential influence on the various parameters of worker physical, psychological, and social adjustment. As a consequence, the implementation of a specific work regime represents a compromise rather than an ideal'' (28) (box 5-C).

The variable parameters of a schedule include fixed or rotating shifts, direction and speed of

Box 5-C—The Philadelphia Police Story

In 1983, a shift rescheduling program was conducted for the City of Philadelphia in an effort to enhance the work schedules employed by the city's police department. The two-phase project was carried out in one of the city's police districts. It consisted of an evaluation of the existing schedule and the design of an improved schedule (phase 1), as well as the implementation of the new schedule and an education program for the officers (phase 2). (Table 5-C-1 compares the old and new schedules.)

In phase 1 of the study it was found that the existing four-platoon work schedule had a number of deleterious effects on the officers. This included 50 percent of the officers reporting poor quality sleep; 80 percent reporting that they fell asleep at least once a week while on the night shift; 25 percent reporting that they had been involved in an actual or near-miss automobile accident due to sleepiness during the past year; over 75 percent of officers' families being dissatisfied with their work schedules; and 35 percent taking either an entire week to adjust or never adjusting to the weekly shift rotation.

In phase 2 of the study, a three-platoon system was initiated for 177 officers, and educational sessions were conducted during the implementation process. The new schedule incorporated proportional staffing (so the number of officers on duty was proportional to the number of calls for service), reversal of shift rotation from counterclockwise to clockwise, reduction in the rate of shift rotation from 1 to 3 weeks, and the elimination of regularly scheduled 6-day weeks (see table 5-C-1). Following implementation of the new schedule there was a fourfold decrease in the number of officers reporting poor sleep, twice as many reporting no daytime fatigue, a decrease in the number of sleep episodes on the job, a decline in the on-the-job motor vehicle accidents per mile driven, an increase in the level of alertness on the night shift, and a reduction in the use of sleeping pills and alcohol. Families of officers reported a nearly fivefold increase in satisfaction with the new schedule.

This study shows that considering biological rhythms when designing a shift schedule for a specific work setting can lessen the negative effects that can occur. It also points out the importance of coupling schedule redesign with educational programs for the workers to assist them in adjusting.

Table 5-C-1—Original and Newly Instituted Schedules for the Philadelphia Police Study

	Schedule	
Characteristic	Old	New
Day off schedule	(6 on, 2 off)	(4 on, 2 off)
Shift length (hours)	8.0	8.5
Maximum consecutive workdays	6	4
Direction of rotation	counterclockwise	clockwise
Average workweek (hours)	40	39.8
Number of platoons	4	3
Average workdays per year	261	244
Total hours worked per year	2,080	2,068
Rotation cycle (days)	8	18
Rotation per year	46	20
Average number of days off per year	104	121
Average number of 12x8 shifts per year	92	80
Number of weekend days off per year	30	34-35

SOURCE: Center for Design of Industrial Schedules, *Final Report on the Philadelphia Police Department Shift Rescheduling Program*, prepared for the Fraternal Order of Police Lodge No. 5, Philadelphia, PA (Boston, MA: Center for Design of Industrial Schedules, 1988).

rotation, length of a shift, and the starting time of a shift. Fixed shifts should result in the least circadian disruption, assuming workers maintain the same schedule on days off as on workdays. They often do not, however, and under such conditions permanent shift schedules take on the nature of a rotating shift (56). Also, as discussed earlier, permanent night workers often suffer from chronic sleep disturbances and are permanently out of synchrony with the rest of society. This latter factor, depending on an individual's personality and family situation, may cause significant social and domestic strain.

Direction of Rotation

Based on the fact that under free-running conditions the human body clock has a natural tendency to run slow, with a preferred period slightly longer than the 24 hours of nature and society (176) (see ch. 3), the human circadian system appears to adjust more slowly to phase advances than to phase delays (13,81). From a circadian perspective, then, clockwise shift rotation (mornings, then evenings, then nights) should be easier to cope with than counterclockwise rotation (nights, then evenings, then mornings). Although this hypothesis still needs to be properly tested, there is some evidence to support it (36). However, a study that used survey data from a group of workers indicated that, in terms of the amount of time available for sleep, a counterclockwise schedule afforded more opportunity to prepare for and recover from the night shift (48). Furthermore, it is possible that the timing of a worker's actual sleep, which can be influenced by social demands, does not necessarily coincide with an ideal circadian schedule (160).

Speed of Rotation

The speed of rotation in a shift system is the number of days an individual spends on a particular shift before switching to a new schedule or to days off. There are a multitude of different shift schedules currently in use (85,150). Many of them approximate a weekly rotation, with an employee working from 4 to 7 days on a shift before changing. However, faster (1 to 3 days) or slower (more than 7 days) rotating systems may also be used.

A rapidly rotating system, as noted earlier, will result in the individual's circadian system remaining diurnal, since not enough time elapses for circadian rhythms to adjust to a new routine (56,105). This avoids the problems associated with a circadian system that is going through a phase adjustment to a new schedule. Also, the shorter rotation does not allow a sleep debt to accumulate, since the number of consecutive days when the worker has to engage in day sleep remains small. The tradeoff is that, while they are on night shifts, workers will be out of synchrony with their circadian systems and performance could be affected (56,105). Also, rapid rotation may have a greater impact on family and social interactions because of the continual schedule changes (56).

A slowly rotating schedule has the advantage of allowing greater time for circadian readjustment. A study of 42 shift workers at a surface mine showed that some measures of adjustment (mood, episodes of awakening during sleep) improved during the second week of a 2-week shift rotation (46). However, a slowly rotating schedule can result in sleep debt and fatigue due to more consecutive periods of day sleep. This problem can be exacerbated if the worker reverts to a diurnal schedule on days off.

Since a weekly shift rotation results in both insufficient time for the body clock to readjust completely and enough time to build up a sizable sleep debt (158), it is this schedule of rotation that is most likely to produce physiological problems (8,36,140,146). However, a weekly system may have the advantage of allowing a worker to engage more easily in social and family activities (56).

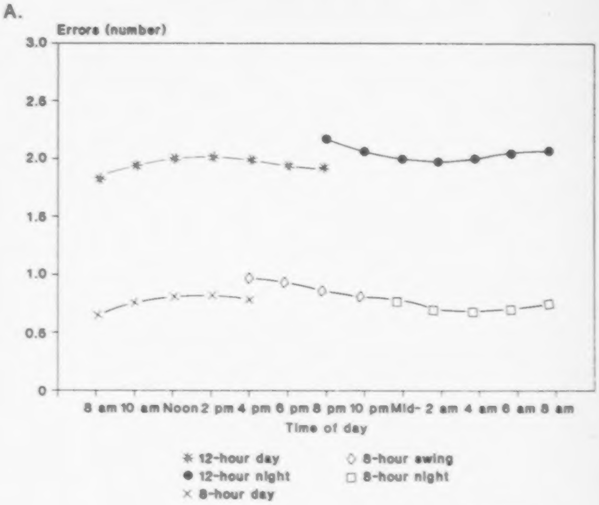
What is the best rotation system to use? Expert opinion is divided. Many favor rapid rotation with very short (1- or 2-day) rounds of duty on one shift before changing to a different one (3,140). Others favor much slower rotation speeds, with 3 weeks or more at one shift before moving to a different schedule (36,111). One factor that may help determine the most desirable speed of rotation is the task to be performed. As previously discussed, there is some evidence that different tasks not only have different best times during the circadian cycle, but also adjust at different rates to a change in routine (56,57). It may be that simple, repetitive tasks, which are performed relatively poorly at night and adjust rather slowly, would be best performed using a slow shift rotation, which allows circadian synchronization to be maintained for longer periods. Tasks involving immediate retention and high memory loads might be performed relatively well during the night shift, even in diurnally oriented individuals (107). In these cases, rapidly rotating shifts might be more suitable: the circadian system retains its diurnal orientation, and there is no gradual buildup of sleep loss (158). Further information is needed to determine whether the speed of shift rotation can have differential effects on various types of tasks. If the main goal is to minimize physiological disruption, a weekly rotating shift seems to be the least desirable; either a more slowly (36) or more rapidly (83,179) rotating system may be preferred.

Shift Duration

In rotating shift systems, the length of a shift is typically 8 hours, although longer shifts, often 12 hours, are sometimes used. The advantage of 12-hour shifts is that the workweek is compressed into 3 or 4 days, giving the worker more days off for leisure and recuperation. The disadvantage is that the extra 4 hours of work per day could lead to increased fatigue and decreased alertness on the job. Such effects have been demonstrated in both laboratory (139) and field studies (134,138). In one field study, conducted at a nuclear powerplant, it was shown that workers on a 3- to 4-day, 12-hour shift system reported increased fatigue and performed more poorly on tests designed to measure alertness than did workers on a 5- to 7-day, 8-hour system (138). These effects were most pronounced in the 12-hour night shift, where there was an interactive effect between fatigue and the low point of the circadian cycle. Interestingly, despite these decrements, examination of performance on job tasks (e.g., filling out log books, occurrence of unusual events) conducted at the same time as the other testing indicated no difference between the 8- and 12-hour shift systems (96) (figure 5-10).

A comparison of the number of health complaints reported by workers in the chemical industry in Germany showed no difference between a rapidly rotating 12-hour and a weekly rotating 8-hour shift schedule (62). The use of a compressed workweek with 12-hour days is also becoming more common in nonrotating shift schedules (see ch. 4). While compressed workweeks are generally well received by workers, they raise concerns about fatigue effects, longer exposure to workplace hazards (e.g., noise, chemicals, repetitive motion tasks), and complications associated with workers holding a second job (29). Also, workers who have long commutes may be at greater risk driving on the highways. Additional studies are needed to fully evaluate these factors and to determine how the extended workday can affect performance and safety, especially in regard to night shifts, where circadian effects would also be present. As with speed of rotation, the type of job to be performed might affect whether 12-hour shifts are appropriate. Long shifts may be more suitable in jobs that do not require intense concentration, are not monotonous or dangerous, and do not involve heavy physical activity (102).

Figure 5-10—Measures of Performance on 8-Hour and 12-Hour Shifts



B.

Shift	Mean	Standard error
8-hour, day	0.174	0.028
8-hour, swing	0.188	0.028
8-hour, night	0.164	0.022
12-hour, day	0.194	0.025
12-hour, night	0.112	0.014

A) Number of errors, by time of day, on a laboratory measure of performance (grammatical reasoning task) for workers on 8-hour and 12-hour shift schedules. Significant performance decrements occurred on the 12-hour shift. B) The average number of errors of entering data into log books per hour on 8-hour and 12-hour shifts. There were no differences between shifts.

SOURCE: P.M. Lewis, D.J. Swaim, and R.R. Rosa, *Evaluation of the 12-Hour Shift Schedule at the Fast Flux Test Facility* (Richland, WA: Pacific Northwest Laboratory, 1986).

Extended duty hours almost invariably result in loss of sleep and fatigue. As previously described, extended periods of sustained work can lead to impaired performance in most psychological tasks. As a result, periods of extended duty hours without adequate time to recuperate from fatigue and lost sleep can have detrimental effects on worker performance and safety.

Because of their disruptive nature, schedules that divide the day into multiple work shifts interspersed with rest periods—namely, split shifts—are rare. The most common use of split shifts is for standing watch aboard merchant and military ships, where a 4-hours-on, 8-hours-off schedule is often employed. These schedules have been shown to result in performance decrements (32,142) as a result of circadian rhythm disruption and disturbed sleep. A more detailed discussion of the shipboard schedules used in the military is presented in chapter 9.

Sleeping and Napping Strategies

One of the major problems facing shift workers is loss of sleep and the resulting on-the-job sleepiness (5,29). Sleeping and napping strategies designed to optimize sleep could be useful interventions for the worker. It has been noted that the majority of night shift workers sleep after work, while day shift workers most often sleep before work (151). It has been hypothesized that delaying sleep after working a night shift is preferable, since such a schedule would maintain a normal work-off-sleep sequence and sleep would occur during a period in the circadian cycle more conducive to longer sleep (45). However, there is little empirical evidence available regarding this strategy. One survey of 328 workers at a surface mine and two powerplants found that those who delayed their sleep after a night shift were less sleepy than those who slept earlier, but they were also more likely to report health complaints (45). Since this was a survey study, it could not be determined if there was a causal relationship between the sleep schedule employed and the incidence of health complaints.

Napping strategies may be useful in two ways. **Brief naps taken during temporary periods of extended work may enhance subsequent performance, and naps taken during time off may help to offset the sleep debt typically associated with shift work.** With respect to on-duty napping, it is known that a sleep period of 1 to 4 hours can lessen sleepiness during a 24-hour period of continuous activity (44,91). One study has shown that airline pilots who were allowed to nap for a short time during a slack period in a flight were more alert when their workloads increased (during landings) than pilots who did not nap (68). Other studies have shown that naps taken early in a period of extended work (42,44) may be more effective in preventing sleepiness than naps taken later during the work period are in recovering from sleepiness (133). In prolonged work schedules (over 24 hours), measures of performance were improved following prophylactic naps, although performance did not return to normal levels (42,44). This indicates the usefulness of prophylactic napping during temporary periods of extended work. The placement of the naps in relation to the circadian cycle was not a factor in the ability of the naps to produce their effects. Also, the enhanced performance occurred only after the residual effects of sleep had worn off: performance decrements can persist for up to an hour after awakening (9) and may be a limiting factor in the use of naps in work settings where a worker must be fully alert on awakening.

Napping at appropriate times during time off may also enhance performance by offsetting the sleep debt that typically accompanies rotating shift work. Recent findings indicate that napping may be an integral component of the circadian sleep-wake cycle (22,25,26,41). Workers who cannot sleep for more than 4 to 5 hours during their initial attempt (a common complaint among shift workers trying to sleep during the day) (60,172) may be able to obtain a couple of additional hours if sleep is attempted again later in the day (9). It has been suggested that a rotating shift worker should not take a nap if the next major sleep period after a work shift is to be at night. A nap under these conditions could interfere with that night's sleep. If the next night is going to be another period of work, however, a nap may be beneficial (9). Also, a nap taken regularly at the same time of day could act as an anchor, or synchronizing point, for circadian rhythms and might slow the adaptation of the rhythms to a new schedule. This could be advantageous to a worker on a rapidly rotating schedule but detrimental to one on slowly rotating shifts (135). Thus, naps can be beneficial and provide a period of additional sleep for shift workers under some conditions; however, napping during the day ultimately interferes with the ability of permanent night workers to get an adequate, extended period of sleep (154).

Light

As discussed in chapter 3, laboratory studies have confirmed that bright light (i.e., light that is equivalent to outdoor light at dawn) can act as a resynchronizing agent for the human circadian system (34,98,177). This has led to the investigation of whether exposure to light can facilitate the circadian adjustment of an individual to shift work (box 5-D). Rigorous use of goggles, lightproof bedrooms, and banks of bright lights has in some cases entrained subjects to non-24-hour routines (50,52).

A recent study of simulated shift work has shown that a fixed schedule of exposure to bright light

Box 5-D—Astronauts and Bright Light

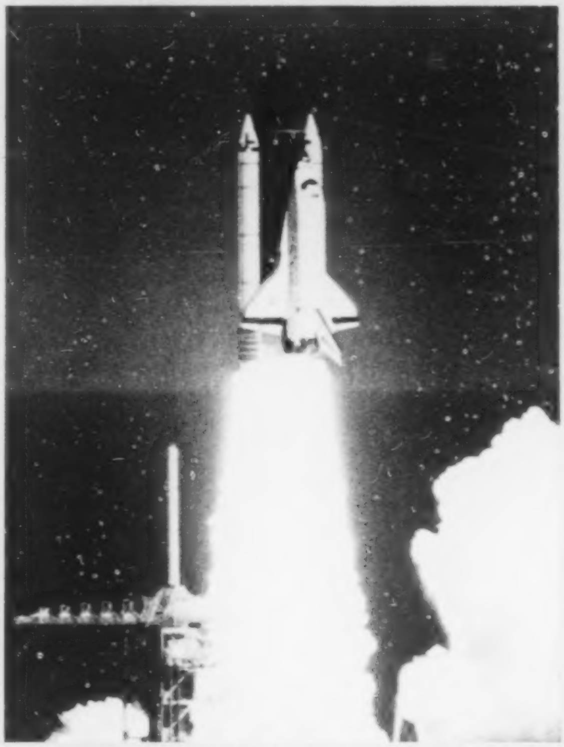


Photo credit: National Aeronautics and Space Administration

Recently, exposure to bright light has been used to help astronauts prepare for a space shuttle mission. The schedule for the December 1990 mission of the space shuttle Columbia called for half the crew to work the night shift, running the ship and carrying out experiments during their nighttime. The previous May, when the Columbia was originally scheduled to be launched, the astronauts had prepared for this schedule by staying up at night and sleeping during the day. Although that launch was canceled, the astronauts reported that simply adopting the new schedule for 2 weeks prior to the launch was not very helpful. One astronaut stated, "I didn't sleep well, I didn't eat well. I was exhausted." In preparation for the new launch date in September, a bank of lights was installed in the astronaut crew quarters, and the night shift crew not only adopted the night schedule but was exposed to bright light during the time they were awake. The September launch date was also canceled, and the bright light treatment was again used for 1 week prior to the launch of the Columbia in December.

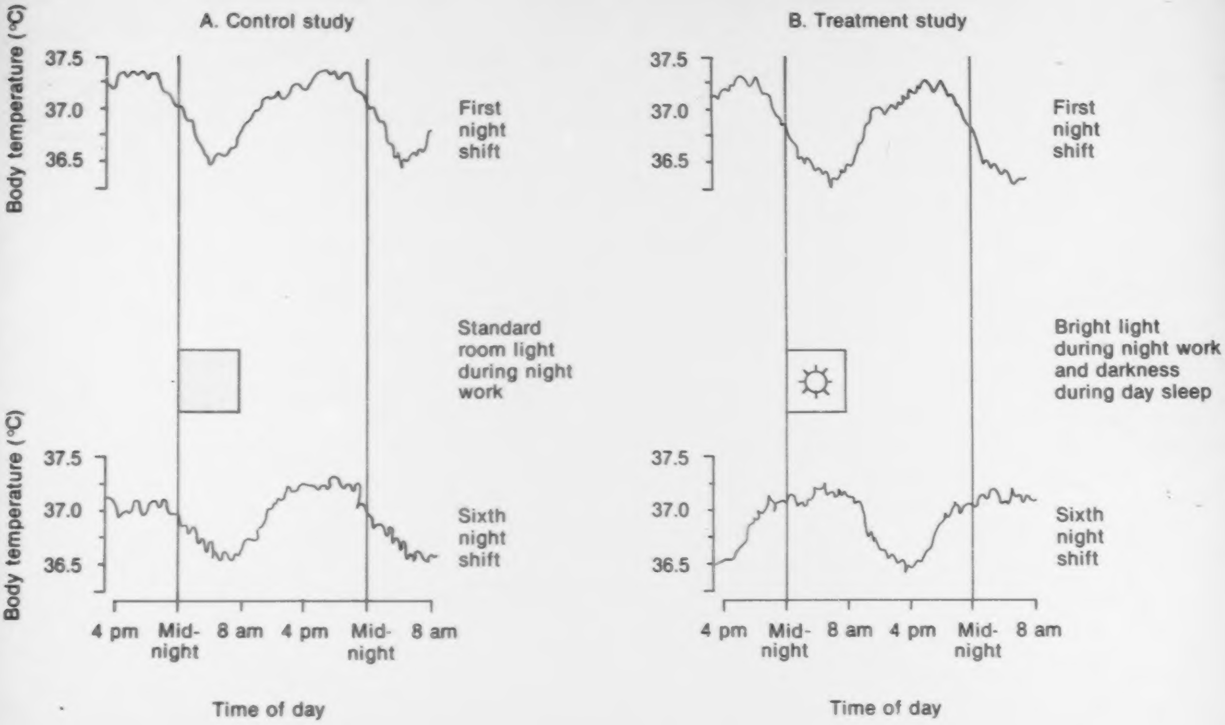
Subjective reports from the astronauts indicated that the bright light exposure, compared with their previous attempt to adjust to the schedule in May, allowed them to sleep more soundly during the day and remain more alert during the night, throughout the mission. As one astronaut said, "We all felt better. The lights did the trick." Operational constraints of the mission prohibited the collection of physiological measures of circadian rhythms which could be used to determine if the astronauts' circadian rhythms had actually been shifted. However, following the cancellation of the September launch, melatonin levels were measured in the astronauts on what would have been the third day of the mission. Melatonin levels were elevated during the astronauts' daytime sleep and suppressed during their waking night. Since melatonin is only released during the biological nighttime hours, this indicated that the astronauts' circadian rhythm of melatonin release had been shifted.

While more comprehensive laboratory and field studies have to be carried out to confirm and extend these observations, these results suggest that the use of bright light might have a role in helping astronauts adjust to their schedules during manned spaceflight. Based on this experience, the National Aeronautics and Space Administration plans to continue exposing astronauts to bright lights before missions that require major sleep changes.

SOURCES: C.A. Czeisler, A.J. Chiasera, and J.F. Duffy, "Research on Sleep, Circadian Rhythms and Aging: Applications to Manned Spaceflight," *Experimental Gerontology*, in press; E. Rosenthal, "Pulses of Light Give Astronauts New Rhythms," *New York Times*, Apr. 23, 1991, p. C1; M. Dunn, "Bright Light Helps Astronauts Adjust to Offbeat Hours in Orbit," *Associated Press*, Feb. 26, 1991.

during night work, combined with complete darkness during daytime sleep, enhanced circadian readjustment to night work, compared to exposure to normal room light at night and unrestricted sleep conditions during the day (35) (figure 5-11). The adjustment was observed in both physiological (body temperature, cognitive performance, urine production) and psychological (subjective alertness, cognitive performance) measures. While it has been noted that the design of this study did not preclude other factors, such as activity and sleep-wake schedules, from contributing to the circadian re-

Figure 5-11—Effects of Bright Light on the Adjustment of One Worker to Shift Work



The body temperature of a worker on the first and sixth nights of work A) with exposure to normal levels of light and B) with exposure to bright light during the second to fifth night of work. Exposure to bright light led to a shifting of the body temperature cycle to coincide with the night work schedule (midnight to 8 a.m.).

SOURCE: Adapted from C.A. Czeisler, M.P. Johnson, J.F. Duffy, et al., "Exposure to Bright Light and Darkness To Treat Physiologic Maladaptation to Night Work," *New England Journal of Medicine* 322:1253-1259, 1990.

adjustment (24), the results do indicate a role for exposure to light and darkness in circadian adaptation to night work. It is likely that exposure to light and darkness as well as activity levels can interact to affect circadian readjustment (164). It has been proposed that circadian adjustment to shift work might be facilitated by manipulating both sleep schedules and exposure to light (51). Another study of exposure to bright light during the night and complete darkness during day sleep showed that the timing of the exposure to bright light determined the direction of the phase shift in circadian rhythms (52,53).

Exposure to bright light may also enhance certain types of performance (23,61) during rotating shift work or extended duty hours. **Thus, there is some initial evidence for the usefulness of bright light to enhance adjustment to work schedules; however, practical application in the workplace must await additional research.**

Medication and Drug Therapies

Drugs might be helpful in counteracting the sleep and fatigue problems common to shift work. One possible intervention, then, would be to improve sleep by the use of hypnotic medication; however, there are two major problems associated with the use of hypnotics.

The first problem is that of residual effects, which leave a person drowsy after awakening. These effects (which are characteristic of long-acting hypnotics) can affect the person's performance and could therefore cause problems in shift work. The development of the short-acting benzodiazepines such as triazolam and brotizolam, which have a half-life of only a few hours (145), has to some extent overcome these problems. It has been shown that triazolam significantly increases the duration of day sleep, although this increase did not appear to increase phase adjustment of the circadian clock, which would have decreased the tendency to fall asleep in the early morning hours (169). This tendency was unaffected by triazolam. Although triazolam will improve daytime sleep for individuals on night shifts, it does little to improve alertness at night (associated with improved daytime sleep) and nothing to improve nighttime performance (170,171).

The second problem regarding the use of hypnotics by workers relates to the chronic nature of the sleep problems associated with shift work. No hypnotic drugs are recommended for anything other than occasional insomnia. The dual problems of tolerance and dependence make it likely that workers would derive little or no benefit from anything other than intermittent use of short-acting benzodiazepines. Moreover, long-term high doses of triazolam have in some cases been associated with amnesia and mood changes (1), effects to which shift workers are especially vulnerable. Thus, for a hypnotic drug to provide any lasting benefit, it would have to be totally benign when administered chronically. In specialized situations—for example, in the military—occasional use of hypnotics can be helpful in inducing sleep during a period of extended duty (e.g., to induce sleep during rest breaks for aviation crews exposed to extended periods of combat) (91). Residual effects are still a concern, however.

An alternative to more potent hypnotics may be mild over-the-counter sedatives, such as antihistamines. These drugs are used by millions of Americans and may aid individuals who have difficulty sleeping (30,92), though these drugs do have side effects which could limit long-term use.

An essential dietary amino acid, tryptophan, has been shown to be helpful in promoting the onset of sleep when administered in sufficient quantities (73,74) without causing a significant impairment in performance (99). Tryptophan is thought to "set the stage for more rapid sleep onset" (147) rather than directly inducing sleep. While tryptophan is a naturally occurring substance and is considered safe, the chronic nature of the sleep problems associated with shift work could limit its use. Whether the intake of a high dose of a single amino acid over an extended period can still be regarded as natural is debatable and has not been tested. Recently, there have been reports of increased incidence of a rare blood disorder associated with the use of tryptophan. This side effect has been traced to the presence of a contaminant that was inadvertently introduced during the manufacture of the compound and not to tryptophan itself. Currently, the sale of tryptophan in the United States is prohibited until its safety can be confirmed.

The regular use of stimulant drugs to maintain alertness (as opposed to maintaining or inducing sleep) in shift work also raises concerns. While there is some evidence that the use of caffeine can increase vigilance (99) and may help to increase alertness and performance on the night shift (18,168), its use can have detrimental effects on sleep and may cause anxiety, nervousness, and gastrointestinal discomfort in high doses. As with hypnotics, the occasional, controlled use of more powerful stimulants (e.g., methamphetamine, dextroamphetamine) has been studied to meet the demands of extended duty in military situations (39,91). But concerns about the possible abuse of these drugs and about the side effects associated with them, such as irritability, distorted perception, apprehension, rebound effects (e.g., depression, fatigue), and psychosis after long-term exposure, make their general use inappropriate. Further study is needed to determine the efficacy of short-term use of stimulants such as caffeine in shift work, especially in occupations in which optimal performance is necessary (e.g., pilots). Any potential benefits would have to be weighed against the problems associated with use.

As described in chapter 3, the ability to affect biological rhythms directly and facilitate the resetting of the body clock with drugs is being explored. Such drugs could be used to help the circadian system adjust to changes in work schedules. Both melatonin and triazolam have been studied for their ability to affect biological rhythms. While neither has been conclusively shown to have any such action in humans, there is initial evidence that melatonin has an effect on the circadian system (97,143). In the case of triazolam, the circadian effects that have been observed in experiments with hamsters (161,162) may be an indirect result of the effects the drug has on activity (114).

Currently, no effective pharmacological agents are available to assist workers in adapting to shift

work. Long-term use of drugs to counteract fatigue and to ease sleep problems is probably not desirable, and to date no drugs have been conclusively shown to have an effect on the circadian system.

Monitoring

Another possible intervention is the use of monitoring devices and instruments to detect individuals who may pose a risk to themselves or others because their performance is impaired. A number of tests have been designed to detect decrements in performance. Some are being used in the workplace to identify individuals who are impaired due to substance abuse, but many are sensitive to other causes of decreased performance. The Automated Performance Test System is a computerized battery of tests that measures alertness and cognitive and psychomotor factors related to job performance. The system can detect impairment caused by sleep loss, drugs, and alcohol, but it does not indicate the cause of the impairment (77,78,124).

Another computerized test battery is the Walter Reed Performance Assessment Battery (157). This battery is designed to examine the effects of sleep deprivation, sustained performance, heat stress, physical fatigue, and physical conditioning in workers. Subjects are asked to undertake a variety of tasks, including ones that measure choice reaction time, time estimation, visual research, pattern recognition, sustained attention, short-term memory, mental arithmetic, and logical reasoning.

Other instruments to measure performance are geared more directly toward determining the effects of fatigue and sleep loss (43,136). The National Institute for Occupational Safety and Health, of the Centers for Disease Control in the Department of Health and Human Services, has developed a Fatigue Test Battery and a Daily Sleep and Habits Questionnaire. Included in the computerized Fatigue Test Battery are a number of brief performance tasks designed to evaluate a range of psychological functions, including cognitive abilities, perceptual-motor functions, motor skills, and sensory acuity (136-139). The Daily Sleep and Habits Questionnaire contains information on sleep and other personal factors known to be affected by work hours. Some questions relate to the times of retiring and arising (including nap times), sleep latency, number of awakenings, depth of sleep, and quality of sleep for the 24 hours preceding the work shift. The workers are also asked to give their subjective evaluation of psychological stress and of gastrointestinal conditions, to report on personal schedule adjustments attributable to shift, adjustments of mealtimes, and exercise periods (138).

These testing instruments are designed to screen individuals to determine if their performance on a task is suboptimal. Other types of monitoring devices are designed to measure and record physiological and performance parameters as an individual actually goes about performing his or her job. These monitoring instruments are valuable for the collection of research and medical data (104). In addition, they provide real-time, on-the-job feedback to the worker, alert the worker to any decrements in performance that may occur, and enable the worker to respond appropriately. Such systems could be particularly useful in job settings where reduction in performance might have negative safety consequences. An example would be a detector that individuals could wear to alert them if they began to fall asleep (117). While such a device would not reverse the person's sleepiness, the feedback it would provide could be crucial in certain settings (e.g., truck drivers, railroad engineers). The design of workplace systems to provide workers with information to judge their performance and to respond to anomalous events would also be valuable (66).

While all of these monitoring procedures might be useful, it has been noted that on-the-job monitoring itself can induce stress (163). Such stress could compound the stress associated with work schedules. Additional research is needed to develop monitoring instruments and systems and to determine the role they could play in various job settings.

Employee Education and Clinical Support

Given the inherent nature of the stress caused by circadian rhythm disruption and the other factors associated with shift work, an important intervention is educational programs that provide workers with strategies to deal with the problems they face and to ease some of the consequences (109). Information such as the best timing of sleep, meals, and other activities to coincide with a given schedule could be helpful. Guidance on ways to make the home more conducive to daytime sleep and the need for cooperation among family members to ensure that the worker is able to get as much sleep as possible would also be beneficial. Finally, providing the entire family with support and guidance that will help them deal with problems that occur could result in a more supportive domestic environment for the worker. Further research is needed to determine what types of educational programs are most effective in helping workers cope with their schedules.

Support for shift workers is largely lacking in U.S. workplaces. Although sleep disorder clinics are available, most of these facilities are not designed to diagnose and handle the underlying problems that cause sleep and other related disorders arising from work schedules.

Fitness

The possibility that improved physical conditioning can increase the rate of adjustment to shift work or increase an individual's tolerance to it has been examined in a few studies (70,71). These studies were conducted on 75 female nurses engaged in shift work and sought to determine whether improving levels of overall fitness would facilitate their ability to cope with shift work. The 4-month exercise training program that was implemented elevated respiratory efficiency by 7 percent. Improvements were noted in self-reports of sleep length, night shift alertness, and general fatigue. Another study failed to show any effect of physical conditioning on the adaptation of wake-sleep and body temperature rhythms to a change in work schedule (135). Thus, the data collected so far suggest that the benefits of physical conditioning may be related to an increase in general strength and more positive subjective reports rather than to any direct facilitation of adjustment to shift work. While these studies indicate that physical fitness might be helpful, additional research is needed to confirm these results and to delineate clearly what mechanisms produce the observed effects. It has also been noted that while physical fitness may lessen the effects of physical and mental fatigue, it cannot protect against the effects of sleep loss (16).

RESEARCH NEEDS

Substantial progress has been made in understanding the underlying physiological mechanisms involved in the generation, entrainment, and expression of circadian rhythms in animals over the last two decades. Similar advances in the application of these data to workplace issues have not been made or supported in this country. A principal need is for research into how to apply basic knowledge on circadian rhythms and sleep to field studies in the workplace. Since demands differ from one workplace to another, research is needed to establish common chronobiological principles, as well as task-specific applications, that can be transferred from the laboratory to the workplace. While some research programs, notably those of the Department of Defense and NASA, use this approach, it is necessary to apply it also to civilian shift work—and not only in industrial settings, but in other settings as well (e.g., police work, long-distance transportation, and medical care). Physiological parameters, such as brain activity, temperature, and endocrine levels, need to be monitored and associated with psychological states and performance measures in order to better understand how functioning is perturbed and how perturbations could be ameliorated. While laboratory studies can attempt to mimic and isolate relevant variables, they cannot fully identify or simulate all the factors present in natural situations.

Research designs need to incorporate enough people over enough time to obtain statistically and biologically meaningful data. Furthermore, analytic models similar to those developed for operations research are needed to take into account the multiple input and output variables. The traditional experimental-control design may not be adequate for many of the research questions that need to be addressed.

Research is needed on the variables that contribute to difficulties in adjusting to shift work. Factors such as individual differences in circadian rhythms, sleep patterns, personality, and age may play a role in the ability of an individual to cope with a work schedule. Studies of the roles of familial and nonwork social demands on the shift worker are also needed. Living in a society that has a different timetable can impose extra burdens on the worker, producing additional stresses on his or her health and well-being.

Sleep loss and fatigue induced by shift work are dependent not only on duration of work, but also on time of day and time of cycle. These parameters need to be documented, and their roles in the ability of workers to perform safely and effectively need to be established. The complex effects of biological rhythms, health status, and drug and alcohol use on performance of workers exposed to the additional physiological stresses of disturbed sleep and circadian rhythms have largely been ignored by researchers.

In addition, there is a compelling need for more research on the interaction between work schedules and safety in the workplace. Central to this endeavor is more thorough collection of workplace data regarding hours of work and the occurrence of on-the-job accidents. Increased data collection by relevant Federal agencies would greatly facilitate this process.

All of the previously stated areas of research will contribute to the final area of research activity—the development of appropriate intervention techniques or countermeasures to promote coping and improve adaptation to shift work. Linked to this is the need for adequate surveillance of workplace performance and evaluation of the effectiveness of potential interventions.

SUMMARY AND CONCLUSIONS

The disruption of biological rhythms that occurs as a result of nonstandard work schedules can interact with other factors to degrade the sleep, health, performance, and well-being of individuals. Although the degree to which different schedules have these effects, which types of tasks are affected most, what variables make an individual susceptible to them, and what interventions can be taken to lessen the effects have not been clearly delineated, some general conclusions can be drawn.

The stresses associated with disruption of circadian cycles, sleep deprivation, and social disharmony interact and affect a number of areas. Shift work is associated with increased incidence of gastrointestinal problems, may be a risk factor for other health problems, and for some workers results in a general, chronic malaise. Performance on some types of tasks can be diminished, especially in those settings where sleep loss and fatigue compound the effects of circadian disruption. These performance decrements can compromise the safety of the worker and can threaten public safety as well.

While the most direct intervention is to devise schedules that do not lead to these consequences, the development of a single best type of schedule is not possible. The demands of a given job will help dictate what might be best in that situation. The avoidance of weekly rotating schedules may be most preferable from a circadian perspective, and schedules that incorporate extended duty hours which result in sleep loss and fatigue should be avoided. Beyond managing schedules, implementing educational and support programs regarding biological rhythms, sleep, and family counseling may be a good way to improve the coping ability of shift workers. The development and use of such mechanisms as bright light and drugs to help the circadian system resynchronize and napping strategies to counteract the effects of sleep loss and fatigue would also be beneficial to workers. Finally, the development of monitoring devices and systems that could be used to assess performance capabilities could also play a role in intervention.

Thus, while general information is available on biological rhythms and shift work, specific information is lacking. There are a number of areas in which there are gaps in the base of knowledge. The information derived from additional research will define the nature, characteristics, and magnitude of the effects caused by work schedules. This knowledge will guide the design and implementation of intervention measures, which are necessary to reduce job-related stress, health effects, and fatigue and to improve alertness and safety.

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Chapter 6

Legal and Regulatory Issues

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Chapter 6
Legal and Regulatory Issues

This chapter addresses legal and regulatory issues related to work schedules and hours of work, referred to generally as work schedules. In particular, it discusses Federal and State regulation, including statutes and regulations currently in place and potential areas of regulation under existing authority. The discussion will consider several categories of statutes:

- statutes relating directly to work schedules and hours of employment;
- safety and health regulatory statutes not dealing directly with work schedules (to the extent that work schedules are shown to affect the safety and health of employees and the public, these statutes could be an important source of legal authority to regulate schedules); and
- statutes that protect the collective rights of employees (work schedules are included in collective bargaining agreements).

The chapter also addresses a number of legal issues related to work schedules, among them:

- the relationship between Federal and State regulation;
- various types of mechanisms to enforce the legal requirements, as well as their advantages and disadvantages; and
- the regulation of public employees.

CURRENT AREAS OF REGULATORY ACTION

A distinction in Federal regulatory structure should be emphasized at the outset. In some cases, such as the Hours of Service Act in the railroad industry, requirements regarding work schedules are included in the statute itself and therefore could be modified only by legislative action. In other instances, the statutes give an administrative agency quasi-legislative authority, and the requirements are promulgated in rules issued by the agency, for example, the regulation of hours of work of air personnel by the Federal Aviation Administration (FAA), in the Department of Transportation (DOT). Changes in these requirements could therefore be made by the agency through amendments to the rules.

Hours of Service Act

It is not surprising that the earliest Federal regulation of work schedules took place in industries where public safety is an important factor. Early Federal regulation of railroads was concerned with the integrity of the physical equipment and imposed requirements for safety equipment on railroad engines and cars (see Safety Appliance Act, 45 U.S.C. 1 *et seq.*). However, it was clear that significant hazards to employees and travelers existed because of the failure of some employees responsible for operations to discharge their responsibilities in a safe manner. This led to enactment of the Hours of Service Act (HSA) in 1907 (45 U.S.C. 61 *et seq.*). The Supreme Court has recognized that the purpose of this statute was to avoid dangers to employees and to the public when employees do hazardous work for such long periods that they are unfit and their judgment is compromised (3). Responsibility for enforcement of this statute originally rested with the Interstate Commerce Commission. When DOT was created in 1966, this responsibility was transferred to the Secretary of Transportation and the Federal Railroad Administration (FRA) [Public Law 89-670 (1966); 49 U.S.C. 1655(e)(2); 49 U.S.C. 102 (DOT); 49 U.S.C. 103 (FRA)].

Although the HSA has been amended several times since 1907, its basic requirements have remained the same. In addition to the work schedule requirements in the law itself, FRA has issued rules under the act that impose requirements for recordkeeping and reporting and govern construction of employee sleeping quarters (49 CFR 228).

The HSA applies to any common carrier engaged in interstate or foreign commerce by railroad [45 U.S.C. 61(a)]. Employees commonly covered include locomotive engineers, firefighters, conductors, train operators, and switch operators (49 CFR 228, app. A). The act makes it unlawful for a common carrier to require or permit an employee who has been continuously on duty for 12 hours to continue on duty or go on duty until he or she has had at least 10 consecutive hours off duty [45 U.S.C. 2(a)(1)]. The act also makes it unlawful to permit or require an employee to continue or go on duty when he or she has not had at least 8 consecutive hours off duty during the preceding 24 hours [45 U.S.C. 62(a)(2)]. The act includes as on-duty time all time that the employee spends in connection with train movement, as well as all time in the service of the common carrier [45 U.S.C. 62(b) (1990 pocket part)]. Time on duty begins when an employee reports for duty and ends when he or she is released from duty. It includes periods for rest at other than designated terminals [45 U.S.C. 61(b)(3)]. An exception to these limitations is provided for crews of a wreck or relief train when the crew's work is related to an emergency, in which case employees may remain on duty for 4 additional hours in any period of 24 consecutive hours [45 U.S.C. 62(c)].

The HSA specifies that the common carrier must also provide sleeping quarters for employees which afford an opportunity for rest free from interruption caused by noise under the control of the railroads [45 U.S.C. 62(a)(3)]. Similarly, sleeping quarters may not be constructed in or near areas where railroad switching and humping operations are performed [45 U.S.C. 62(a)(4)]. These requirements have been interpreted in FRA rules, which, among other things, define the distance requirements for sleeping quarters and specify procedures for approval by FRA of construction plans for sleeping quarters (49 CFR 228, subpart C).

The HSA also limits hours for other categories of employees, that is, those not actually engaged in or connected with train movements. It is unlawful for any employee who uses electrical or mechanical devices to dispatch, transmit, or receive orders affecting train movements to remain on duty for more than 9 hours in a 24-hour period in a place where two or more shifts are employed [45 U.S.C. 63(a) and 1990 pocket part]. The same is true for 12 hours in a 24-hour period where one shift is employed [45 U.S.C. 63(a)(2)]. Special authorization is given for 4 hours of additional service in a 24-hour period in case of emergency, but not exceeding 3 days in 7 consecutive days [45 U.S.C. 63(c)]. Other work schedule requirements are imposed for individuals engaged in installing, repairing, or maintaining signal systems. An individual who has been on duty continuously for 12 hours may not continue on duty without at least 8 consecutive hours off duty during the preceding 24 hours [45 U.S.C. 63a (a)].

These provisions are the maximum permissible hours of service consistent with safety (45 U.S.C. 64 and 1990 pocket part). However, the HSA also provides that they are proper subjects for collective bargaining under the National Labor Relations Act and the Railway Labor Act (discussed later). That is, a carrier and employee representative may agree to further limit employee work schedules (45 U.S.C. 64 and 1990 pocket part).

A related statute, but one designed for an entirely different purpose, is the Adamson Act, enacted in 1916 and codified together with the HSA (45 U.S.C. 65). The Adamson Act establishes a day's work to be 8 hours, for the purpose of compensation for services (45 U.S.C. 65). Thus, the act does not bar workdays of more than 8 hours, it simply provides that 8 hours is the basis for calculating overtime under the Fair Labor Standards Act and under collective bargaining agreements. The Adamson Act may provide economic incentives for limiting work schedules, but it does not regulate them directly.

Enforcement of the HSA, as noted, is assigned to the Secretary of Transportation (49 CFR 209.1). The Administrator of the FRA is appointed by the President with the advice and consent of the Senate and reports directly to the Secretary of Transportation. The provisions of the HSA relating to manner of enforcement were amended significantly by the Rail Safety Improvement Act of 1988 (45 U.S.C. 64A). The enforcement scheme of the FRA under the HSA and related safety statutes will be discussed in more detail below.

Persons violating requirements of the HSA are liable for civil penalties. The penalties for willful violations may be as high as $1,000 per violation [45 U.S.C. 64a(a)(1)]. The FRA decides whether a penalty is to be assessed. Where no compromise is reached with the offending party, it is the duty of the U.S. Attorney to sue to collect the penalty in a Federal court under the Federal Claims Collection Act [45 U.S.C. 64a(a)(1)].

The FRA's most sweeping enforcement tool, although one that it has used only rarely, is its authority to issue emergency safety orders halting conditions or practices that create a hazard of death or injury to persons [45 U.S.C. 432(a)]. After issuance of the order, it must be reviewed in a trial-like hearing (49 CFR 211.47, 216.21-27). This emergency authority is unique in that it can be used to address unsafe practices and conditions whether or not they contravene an existing regulatory or statutory requirement (49 CFR 209, app. A). The provision has been held by a U.S. court of appeals to apply to conditions or practices that are hazardous under the HSA respecting sleeping accommodations, even though HSA requirements are enforced in court by the U.S. Attorney and not the FRA (21).

The Railroad Safety Act, which became law in 1970 (45 U.S.C. 421 *et seq.*), authorizes the Secretary of Transportation, through FRA, to issue rules for all areas of railroad safety to supplement laws and rules already in effect, including those under the Hours of Service Act. To date, the FRA has not issued any. The FRA's potential to regulate work schedules will be discussed below.

Motor Carrier Safety Act of 1984

The Motor Carrier Safety Act of 1984 (MCSA) is an example of a statute that gives an administrative agency quasi-legislative authority to regulate safety. Congress stated in the preamble to the MCSA that the purpose of the law was to:

- promote the safe operation of commercial motor vehicles;
- minimize dangers to the health of the operators of those vehicles and of other employees whose employment directly affects motor carrier safety; and
- assure increased compliance with traffic laws and with various regulations issued under the act (49 U.S.C. App. 2501).

The MCSA covers commercial motor vehicles defined as:

- vehicles with gross weight exceeding 10,001 pounds;
- vehicles designed to transport more than 15 persons (including the driver); and
- vehicles used to transport certain hazardous materials [49 U.S.C. App. 2503(1)].

Federal, State, and local government employers are not covered by the act.

The Secretary of Transportation is required to issue regulations that, at a minimum, ensure that the physical condition of operators of commercial motor vehicles is adequate to safe operation and that the operation of the vehicles does not have deleterious effects on the physical condition of the operators [49 U.S.C. App. 2505(a)(3),(4)]. Regulations regarding motor carrier safety are exercised by the Federal Highway Administration (FHWA) through the Office of Motor Carriers.

The Secretary of Transportation's responsibility to issue regulations under MCSA has been implemented in part by FHWA regulations entitled Hours of Service of Drivers (49 CFR 395). These regulations relate to maximum on-duty and driving time, drivers' records of on-duty status, and provisions for special circumstances. The regulations also contain provisions for the use of automatic on-board recording devices (49 CFR 395.15) and provide that these devices not be used to harass operators (the latter provision stemming from concern that the devices might be used to spy on drivers). The on-board devices record such things as engine revolutions per minute, vehicle speed, oil temperature and pressure, distance traveled, driving time, breaks, daily rest periods, and compliance with speed limits.

Hours of Service Regulations for Drivers

The basic work schedule limitation in FHWA regulations is that no driver may be required or permitted to drive:

- more than 10 hours following 8 consecutive hours off duty;
- for any period after having been on duty 15 hours following 8 consecutive hours off duty;
- for any period after having been on duty 60 hours in any 7 consecutive days if the motor carrier does not operate every day of the week; or
- for any period after having been on duty 70 hours in any period of 8 consecutive days if the motor carrier operates every day of the week (49 CFR 395.3).

The regulations define on-duty time to include waiting time; inspection time; time spent loading, unloading, or repairing equipment; and time in any motor vehicle, even if not driving. It does not include time spent resting in a sleeper berth meeting FHWA requirements.

In an emergency, a driver may complete a run without violating the regulations if the run can reasonably be completed without such a violation. In the event of adverse driving conditions, such as snow, sleet, or fog, a driver may drive for 2 additional hours to complete a run or reach a safe place; however, a driver may never drive for more than 12 hours following 8 consecutive hours off duty or after being on duty 15 hours following 8 consecutive hours off duty (49 CFR 395.10). These regulations do not apply to carriers transporting passengers or property in order to provide relief in the event of a natural disaster (49 CFR 395.12).

The regulations contain two methods for determining a driver's hours of service. Under the first, the carrier requires the driver to record his or her duty status for each 24-hour period on a specified grid or on a previously approved daily log, in combination with any company forms. Under the other, the carrier requires drivers to use an automatic on-board recording device in lieu of manual recording. The recording device produces on demand an electronic display or printout of the driver's hours of service, including the sequence of duty status changes and each day's starting time (49 U.S.C. 395.15).

Enforcement

Regulations issued under the Motor Carrier Safety Act are enforced by FHWA through periodic random inspections and inspections conducted in response to complaints (49 U.S.C. App. 2509-2511). The FHWA is authorized to impose civil penalties for violations of MCSA in amounts specified in DOT's authorization statutes (49 U.S.C. 521). A penalty of up to $500 may be imposed for violations of recordkeeping requirements. Where there has been a serious pattern of safety violations other than recordkeeping, a civil penalty of up to $1,000 for each offense may be assessed; however, total penalties may not exceed $10,000. If FHWA determines that a health or safety violation resulted or reasonably could have resulted in serious physical injury or death, a civil penalty of up to $10,000 may be imposed for each offense. No penalty may be imposed on an employee except for gross negligence or reckless disregard of safety, in which case the penalty may not exceed $1,000 [49 U.S.C. 521(b) (1)(B)]. A person is entitled to be given notice when charged and to be given an opportunity for a hearing before the penalty becomes final.

The FHWA can order a vehicle out of service or order an employer to cease all or part of its commercial motor vehicle operations if it finds that a violation or combination of violations poses an imminent hazard to safety [49 U.S.C. 521(b)(5)]. Criminal penalties may be imposed on anyone who knowingly or willfully violates the statute or regulations; if the violator is an employee, the penalty is limited and may be applied only if the unlawful activity could have led to death or serious injury. Special agents of FHWA can also declare a driver out of service and therefore ineligible to drive if they determine that the driver has been on duty longer than the maximum period permitted in the regulations (49 CFR 395.13).

Civil Air Safety

The Secretary of Transportation has the statutory duty to promote the safety of commercial airlines by prescribing and revising reasonable rules and regulations governing maximum hours or periods of service of airmen and other employees of air carriers [49 U.S.C. App. 1421(a)(5)]. The FAA has issued numerous safety regulations under its statutory authority, including limitations on duty and flight time and rest requirements for various categories of covered employees [14 CFR 121(P-S)]. Enforcement of FAA safety rules is governed by provisions of the Federal Aviation Act (49 U.S.C. App. 1471 *et seq.*) and the implementing regulations (14 CFR 13.15,13.16) and includes agency authority to impose civil penalties, orders of compliance, criminal penalties, punitive damages, and injunctions (49 U.S.C. App. 1471,1472,1523).

Work Schedule Limitations

FAA has issued rules prescribing duty and flight limitations for pilots, air traffic controllers, engineers, and crew members of various kinds of air carriers [14 CFR 121(P-S)]. Because the rules are detailed and complex, only the flight time limitations and rest requirements for crew members of domestic air carriers will be summarized here.

Under the rules, a domestic air carrier is not permitted to issue, and a flight crew member may not accept, an assignment for flight if the crew member's total flight time will exceed:

- 100 hours in a calendar month;
- 30 hours in 7 consecutive days; or
- 8 hours between required rest periods.

In addition, a flight crew member may not be assigned flight time during the 24 consecutive hours preceding the scheduled completion of any flight segment unless he or she has a scheduled rest period of at least:

- 9 consecutive hours for less than 8 hours of scheduled flight time;

- 10 consecutive hours for 8 to 9 hours of scheduled flight time; or
- 11 consecutive hours for 9 or more flight hours.

These rest requirements may be reduced if a rest period of a specified length is scheduled to begin no more than 24 hours after the reduced rest period.

The rules further require that the crew member be relieved of all duty for at least 24 hours during any 7 consecutive days and prohibits the assignment or acceptance of any duty during any scheduled rest period. The rules also provide that flight time does not include:

- time spent in transportation provided to the crew member by the carrier to and from the airport; and
- time when the airplane does not reach its destination within the scheduled time because of circumstances beyond the control of the carrier [14 CFR 121(Q)].

Separate FAA rules prescribe flight time limitations for pilots and other crew members of flag air carriers [14 CFR 14 (R)] and of supplemental air carriers and commercial operators [14 CFR 121 (5)].

Limitations on duty time for air traffic controllers are also important to safety. Except in emergency situations, a certified air traffic tower operator may not be required to work in excess of:

- 10 consecutive hours or
- 10 hours during a 24-hour period unless he or she has been allowed a rest period of at least 8 hours before or at the end of the first 10 hours of duty.

In addition, an air traffic controller must be allowed at least 1 day off during each consecutive 7-day period (14 CFR 65.47).

Enforcement

The FAA is authorized to enforce the safety requirements of the Federal Aviation Act by means of civil and criminal penalties. Where the FAA believes that an emergency exists, it is authorized, either on its own initiative or on a complaint, to issue an order promptly [49 U.S.C. App. 1485(a)].

Maritime Safety

The U.S. Coast Guard has been part of DOT since 1966, when the Department was created (49 U.S.C. 108). The shipping statute related to work schedules contains specific requirements on the manning of vessels (46 U.S.C. 8101-8105). In particular, the provisions on watches limit hours of service. An officer may take charge of a deck watch on a vessel only if that officer has been off duty for at least 6 of the 12 hours immediately before departure [46 U.S.C. 8104(a)]. On certain oceangoing or coastwise vessels (vessels that only go along the coast), a seaman cannot be required to work more than 9 of 24 hours when in port or more than 12 of 24 hours at sea, except when life or property is endangered [46 U.S.C. 8104(b)]. Similarly, a seaman in a deck or engine department cannot work more than 8 hours in 1 day on a towing vessel, except in an emergency or on certain merchant vessels [46 U.S.C. 8104(c),(d)]. On certain towing vessels, an individual cannot work for more than 12 hours in a consecutive 24-hour period except in an emergency [46 U.S.C. 8104(h)]. Additional statutory requirements related to watches may affect hours of service indirectly, such as provisions concerning the number of watches into which personnel must be divided [46 U.S.C. 8104(1)]. The statute also prescribes certain rest periods and prohibits unnecessary work on Sundays and certain holidays [46 U.S.C. 8104(e)(2)]. In some circumstances, however, such as when work is necessary for the safety of the vessel or saving a life on board another vessel, these restrictions are not applicable [46 U.S.C. 8104(f)].

National Transportation Safety Board

The National Transportation Safety Board (NTSB) is a separate and independent agency made up of five members appointed by the President with the advice and consent of the Senate. The NTSB's primary responsibility is to investigate railway, aircraft, highway, marine, pipeline, and hazardous material accidents in order to determine the probable cause of an accident and to make recommendations concerning safety (49 U.S.C. App. 1903, 1906). **Although NTSB has no direct regulatory authority and cannot require compliance, its recommendations are publicized and may be influential in a number of arenas. Indeed, the law requires the Secretary of Transportation to respond to NTSB safety recommendations, including giving a statement of intent to address the recommendations, together with a proposed procedure and a timetable for adopting them. The Secretary must give a detailed explanation for his or her refusal to adopt NTSB recommendations. NTSB accident reports** and other reports have addressed issues related to hours of service in all modes of transportation.

Nuclear Powerplant Regulation

The Nuclear Regulatory Commission (NRC) was created in 1974 under the Energy Reorganization and Development Act (42 U.S.C. 5841 *et seq.*). It has the authority to regulate the possession and use of nuclear materials, nuclear power reactors and facilities, and persons who use nuclear materials [42 U.S.C. 2201(b); 10 CFR 55].

The NRC has issued a policy statement regarding working hours for nuclear powerplant staff [47 FR 23,836 (1982)]. NRC policy statements are enforceable only if a plant voluntarily incorporates them into its technical specifications as part of the NRC licensing procedure. The policy statement addresses the need to establish controls to prevent situations in which fatigue could reduce the ability of personnel to operate a reactor safely. The controls, which focus on shift staffing and the use of overtime, apply to staff who perform safety-related functions and ensure that such staff are not assigned to shift duties while in a fatigued condition, which might reduce their mental alertness or their decisionmaking ability. The objective is for plants to employ enough personnel so that operating staff work a normal 8-hour day, 40-hour week. However, where unforeseen problems or special circumstances arise necessitating major overtime, the policy offers certain guidelines to be followed. According to the policy statement, an individual, even in emergency situations, should not be permitted to work:

- more than 16 consecutive hours;
- more than 16 hours in a 24-hour period;
- more than 24 hours in a 48-hour period; or
- more than 72 hours in any 7-day period.

In addition, a break of at least 8 hours should be allowed between work periods, and licensed operators at controls should be relieved periodically and given noncontrol responsibilities during their tour of duty [47 FR 23,836 (1982)]. Nuclear powerplant control room operators are discussed in greater detail in chapter 7.

Fair Labor Standards Act

The Fair Labor Standards Act (FLSA), a centerpiece of New Deal employment legislation enacted in 1938, originally:

- mandated a minimum wage rate for covered employees (29 U.S.C. 206);
- required employers to pay an overtime premium for each hour worked in excess of 40 hours in a single week (29 U.S.C. 207); and
- imposed penalties on employers for oppressive child labor (29 U.S.C. 212).

In 1963, the FLSA was amended to provide for equal pay for equal work regardless of sex [29 U.S.C. 206(d)]. The act has also been amended to expand its coverage. It originally imposed statutory requirements only on employers engaged in commerce or in the production of goods for commerce [29 U.S.C. 206(a); 29 U.S.C. 207(a)(1)], but it now includes certain agricultural employees and State and local government employees.

The statutory and regulatory provisions of FLSA relating to who is covered are detailed and complex. Thus, for example, employees in a bona fide executive, administrative, or professional capacity are exempt from FLSA's requirements [29 U.S.C. 213(a)(1)]. Other employees may be exempt from the maximum hour requirements alone [29 U.S.C. 213(b)] and still others from the child labor requirements [29 U.S.C. 213(c)]. The Department of Labor has issued regulations and statements of general policy relating to the coverage of FLSA. Of particular relevance is the extent to which FLSA overtime provisions apply to employees of railroads, motor carriers, airlines, and maritime transportation.

The FLSA is implemented by the Wage and Hour Division of the Department of Labor. The act is enforced primarily through suits brought by the U.S. Government and by private individuals. Criminal penalties, enforced by the Department of Justice, are authorized in some cases [29 U.S.C. 216(a)], and violations of the child labor requirements are enforced by a system of administratively determined civil penalties [29 U.S.C. 216(e)].

Child Labor Provisions

Child labor laws protect children from mistreatment in employment settings and ensure that employment will not interfere with their schooling. Children between 14 and 16 may not work in certain occupations, such as those connected with transportation, under any circumstances [29 CFR 570.33(f)(1)]. In other occupations, employment of 14- to 16-year-olds is permitted if confined to the following times:

Box 6-A—Evolution of the 8-Hour Workday

The 8-hour workday began as a key demand of the labor movement in the United States during the last quarter of the 19th century. The shortened day was advocated as a means of increasing leisure time for workers and as a way to offset the unemployment of workers whose jobs were being taken over by machines. Labor leaders, such as Samuel Gompers, believed that shortening the workday to 8 hours would provide more jobs for those whose tasks were threatened by automation. This did not prove to be true, however, since increased automation led to heightened production, even with fewer workers.

Despite this, the movement for an 8-hour workday continued. In 1938, the concept was codified in the Fair Labor Standards Act under the section regulating maximum hours for workers (29 U.S.C. 207). This section limited the standard workweek to 40 hours, indirectly creating the 8-hour workday. Any work beyond the initial 40 hours required compensation at one and one-half times the employee's regular rate (29 U.S.C. 207).

Reasons for this limitation of hours included the desire for more leisure time and improved morale within the working population, the health benefits of shorter hours, and increased general well-being. Economic factors also enhanced the acceptability of the 8-hour day to the employer. It was thought that shorter hours would ultimately lead to increased health and a reduction of social ills, which would bolster productivity and increase profits.

Furthermore, philosophical and societal goals entered into the reasoning behind the legislation. President Franklin D. Roosevelt stated in a message to Congress on May 24, 1937, "[a] self-supporting and self-respecting democracy can plead no economic reason for chiseling workers' wages or stretching workers' hours. . . . [e]nlightened business is learning that competition ought not to cause bad social consequences which inevitably react upon the profits of business itself. . . . Government must have some control over maximum hours . . . to protect the fundamental interests of free labor and a free people."

SOURCES: Office of Technology Assessment, 1991; *United States Code Congressional & Administrative News*, 89th Congress, vol. 2 (St. Paul, MN: West Publishing, 1967), pp. 3002-3003; *United States Code Congressional & Administrative News*, 93rd Congress, vol. 2 (St. Paul, MN: West Publishing, 1975), pp. 2814-2819; *United States Code Congressional & Administrative News*, 101st Congress, vol. 2 (St. Paul, MN: West Publishing, 1990), pp. 696-697.

- outside school hours;
- not more than 40 hours per week when school is not in session;
- not more than 18 hours per week when school is in session;
- not more than 8 hours per day when school is not in session;
- not more than 3 hours per day when school is in session; and
- between 7 a.m. and 7 p.m. in any 1 day, except during the summer, when the evening hour will be 9 p.m. [29 CFR 570.35(a)].

The regulations also provide for employment of children between 14 and 16 in school-related work and career exploration programs meeting certain requirements. Among those requirements is that the employment shall not exceed 23 hours in 1 week or 3 hours in 1 day when school is in session [29 CFR 570.35A(d)].

Overtime Provisions

Unlike the child labor provisions of FLSA, which directly limit the work schedules of minors, the minimum wage and overtime provisions have only an indirect impact on regulation. The FLSA requires an employer to pay each employee meeting certain requirements a minimum wage (29 U.S.C. 206). Under the overtime provisions, an employer may not employ a worker for more than 40 hours per week unless the worker is paid at one and one-half times his or her regular rate (29 U.S.C. 207). Thus this statute does not prohibit employers from requiring or permitting employees to work more than 40 hours a week, but it does regulate the basic hourly rate and the resulting regular rate on which overtime is based. Box 6-A explains the origin of the 8-hour workday.

Central to both minimum wage and overtime provisions is the determination of hours worked. This can become complicated when it involves issues such as waiting time, rest and meal periods, preparatory and concluding activities, lectures, meetings, training programs, and travel time (29 CFR 785, subpart C). Of particular relevance is its application to sleeping time. An employee who is required to be on duty for less than 24 hours is working even though he or she is permitted to sleep or engage in personal activity when not busy (29 CFR 785.20, 785.21). However, for employees required to be on duty for 24 hours or more, the employer and employee may agree to exclude from hours worked a regularly scheduled sleeping period of not more than 8 hours, as long as adequate sleeping facilities are furnished by the employer and the employee can usually enjoy an uninterrupted sleep [29 CFR 785.22(a)]. No more than 8 hours sleep time can be excluded, however [29 CFR 785.22(a)]. If the sleep period is interrupted to such an extent that the employee cannot get a reasonable amount of sleep, the entire period must be counted as hours worked. According to Wage and Hour Division guidelines, if 5 hours of sleep are not provided, the entire time is work time [29 CFR 785.22(b)]. In a recent case involving overnight relief workers at residential facilities for the mentally retarded, the court held that the employees, though on duty for more than 24 hours, were entitled to compensation for sleep time because of the nature of their accommodations and the frequent need to attend to clients at the facilities (8).

State Regulation

There is a substantial body of State regulation in the area of employee hours and conditions of work, some of which relates directly or indirectly to work scheduling. Because of the extensive nature of the material, only a few examples will be discussed. In considering State legislation, one should bear in mind the possible preemptive effect of Federal regulation of the same subject matter.

A number of States have legislation paralleling the FLSA. An example is Michigan's minimum wage law, enacted in 1964 (11) and last amended in 1980. This law establishes a minimum wage and overtime pay and provides for exemptions for certain categories of employees. Michigan also has in effect a work scheduling law for motor truck and tractor operators (sec. 480.12, 480.13 of Compiled Laws of 1970). Under the law, a person may not drive a motor truck or tractor more than 10 hours in 15 hours, and then only following 8 hours off duty. The law defines duty time as beginning with the person's reporting for duty and ending with the person's release. It further provides that off-duty time may be accumulated in a sleeping berth in two periods of at least 2 hours each (11).

Michigan has also enacted a child labor statute, which imposes work schedule limitations on certain minors. The law does not apply to:

- children over age 15 who have graduated from high school;
- children over 16 who have passed a certain development test; and
- emancipated minors.

In addition to prohibiting certain work entirely, the law makes it unlawful for a person under 18 to be employed in a covered occupation for:

- more than 6 days in 1 week;
- more than a weekly average of 8 hours per day; and
- more than 48 hours in 1 week or more than 10 hours in 1 day.

In addition, the minor may not be employed between 10:30 p.m. and 6 a.m. when school is in session, or between 11:30 p.m. and 6 a.m. when school is not in session. A minor in school may not be employed a combined school and workweek of 48 hours when school is in session. Children under 16 have the same restrictions, except they may not be employed between 9 p.m. and 7 a.m. (11).

Other State legislation focuses generally on work schedule limitations for specific categories of employees, such as minors, and requirements for premium pay for overtime. A notable exception that has attracted wide attention is the recently enacted New York State statute regulating the work schedules of attending physicians and certain postgraduate trainees in hospitals [N.Y. State Code, Title 10, sec. 405.4(a)(6)]. This matter is discussed in more detail in chapter 8. Box 6-B discusses employer liability for accidents caused by a sleep deprived employee in a recent Oregon case.

AREAS OF POTENTIAL REGULATORY ACTION

Regulatory action can arise from the enactment of new (or amended) legislation covering work schedules or from the promulgation of new regulations under existing statutory authority. With respect to the enactment of new Federal legislation, there is no serious question regarding the power and authority of the Congress to take legislative action to regulate work schedules. A long line of Supreme Court cases has established the plenary power of Congress to regulate economic matters, including labor regulation, under the commerce clause of the U.S. Constitution. While Federal legislation could apply work schedule requirements selectively, that is, to some categories of employees but not to others, there would have to be a satisfactory explanation for its

Box 6-B—Employer Liability

"Employment," according to *Black's Law Dictionary*, includes the actual act of working and may include a reasonable amount of space and time necessary to travel to and from the work site. An employer who allows an employee to work too many hours without rest may be found negligent in cases where this employee causes an accident, even after leaving the job site.

Faverty v. *McDonald's Restaurants of Oregon, Inc.*: The jury found McDonald's liable for allowing its employee to drive home after working an all-night shift and awarded Frederic M. Faverty $170,000 for medical expenses and lost wages and $230,000 in general damages. The employee, Matthew A. Theurer, an 18-year-old high school senior, left McDonald's at the end of a 12-hour split shift after asking the manager to schedule another worker for his next shift because he was tired. Theurer began the 19-mile drive to his home but fell asleep behind the wheel and struck Faverty's car head on. Faverty suffered serious injuries. Theurer was killed. Theurer had worked a 5½-hour shift on Sunday night from 6 p.m. to 11:30 p.m. and had attended a full day of school on Monday. On Monday afternoon he began a 12-hour split shift that ran from 3:30 p.m. to 7:30 p.m., resumed at midnight, and lasted until 8:20 a.m. Tuesday. According to testimony, Theurer had complained at school and work that he was tired. He had had less than 7 hours of sleep in the 48 hours before the accident and had not slept at all in the 24 hours preceding the crash.

Faverty sued McDonald's for his injuries stemming from the automobile accident. The jury found that McDonald's knew, or should have known, of Theurer's exhaustion and that he planned to drive home by himself. According to this decision, it should have been foreseeable to McDonald's that Theurer would be operating a motor vehicle and would be a danger to himself and others since he had been awake more than 24 hours. McDonald's is appealing this decision.

SOURCES: Office of Technology Assessment, 1991; based on Associated Press, "McDonald's Loses Worker's Collision Case," *New York Times*, Apr. 1, 1991, p. A12; Case No. 90-0100394, Circuit Court of the State of Oregon for the County of Multnomah; *Black's Law Dictionary*, 5th ed. (St. Paul, MN: West Publishing Co., 1979); M. Lowery, attorney, legal department, McDonald's Corp., Oakbrook, IL, personal communication, June 18, 1991.

doing so. This explanation could consist of data showing particular danger from fatigue in specific industries. Such an explanation would probably be upheld, particularly since legislation singling out certain industrial groups for regulatory purposes has substantial precedent.

At the same time, it should be emphasized that some distinctions in regulatory coverage may be problematic under the equal protection clause of the U.S. Constitution and State constitutions and under civil rights statutes. **Distinctions based on gender and race would be subject to particular scrutiny. Thus, for example, a statute that limited night work for women but not men would be scrutinized very carefully by the court. The argument that women are in need of special protection is no longer acceptable and probably would not stand up in court (17).** Where Federal statutes already include specific work schedule requirements, as for example railroad employees, modification of these requirements may be necessary.

With regard to State legislation, the issue is somewhat more complex. While State legislatures generally have authority to regulate economic matters, they are subject to both Federal constitutional limitations (e.g., due process and equal protection) and State constitutional limitations. In addition, any State regulatory action, whether in the form of a statute, regulation, order, or decision, may be preempted by Federal regulatory action in the same area. The issue of Federal preemption is a complex area of law involving constitutional principles, Federal statutory language and intent, and a substantial body of precedent. Any potential State legislative action or other regulatory action would have to take into account this body of law.

Occupational Safety and Health Laws

The most likely source of authority in regulating work schedules would be safety and health statutes. Some of these deal specifically with occupational safety and health, notably the Federal Occupational Safety and Health Act (OSH Act) (29 U.S.C. 651).

The Occupational Safety and Health Administration (OSHA) was created to implement the provisions of the OSH Act, which covers all private employees [29 U.S.C. 652(5)]. Although Federal and some State and local employees are not covered by the basic OSHA program, they are covered by separate provisions [29 U.S.C. 652(5), 668]. Covered employers have two basic obligations:

- to comply with occupational safety and health standards issued by OSHA; and
- to comply with the general duty clause (see later discussion) (29 U.S.C. 654).

OSHA enforces those obligations through a system of workplace inspections, the issuance of civil penalties of up to $70,000, and citations with abatement requirements [29 U.S.C. 666(a)-(d)]. The OSH Act also includes authority for limited criminal penalties [29 U.S.C. 666(e)].

OSHA Standards

OSHA has issued a large body of standards, generally separated into safety standards and health standards (29 CFR 1900 *et seq.*), but none deals with work scheduling. **If, however, OSHA determined that hours of work pose a safety or health hazard to employees, it could regulate work schedules by issuing a standard.** In considering whether OSHA should take regulatory action on work schedules through the promulgation of standards, a number of factors must be kept in mind:

- **The standard's purpose must be to protect employee safety and health;** OSHA has no authority to issue standards directed solely toward public safety (2).
- OSHA's jurisdiction is broad, and many serious hazards are competing for its regulatory attention. OSHA would have to determine that regulation of work schedules was particularly important before it would take action. With such subjects as AIDS, ergonomic hazards, the hazards of blood-borne diseases to health care workers, and various carcinogens on its agenda, there is serious question whether OSHA is likely to tackle the work schedule issue in the near future. Interested parties may petition OSHA to begin rulemaking on an issue, may make use of political or other means to persuade the agency to act, and may sue in court to force OSHA to act. In some cases, courts have ordered OSHA to undertake rulemaking, but this has been in the context of carcinogens or other special circumstances (15).
- OSHA rulemaking is typically slow, with years elapsing before a final standard is issued and upheld in court. While priority items are often speeded up, such special treatment would not necessarily be accorded to work schedule regulation. On occasion, courts have forced OSHA to complete rulemaking, but this is unusual and takes place only in special situations (16).

General Duty Clause

The general duty clause of the OSH Act [sec. 5 (a) (1)] requires that an employer provide employees with a workplace free from recognized hazards likely to cause death or serious physical harm [29 U.S.C. 654(a)(1)]. Like standards, the general duty clause is enforced through workplace inspections, citations, and penalties. However, enforcement differs in several important respects. When OSHA enforces a standard, the employer's obligations are defined by the standard, which has already entailed a public participation phase and has usually been upheld by a court. Thus, in the enforcement proceeding OSHA need only establish the facts and show that the standard was violated in order to uphold the citation and penalty.

In general duty proceedings, however, the burden on OSHA is greater. There is no specific obligation to be enforced; there are only the more generalized requirements of section 5 (a)(1). To establish a general duty violation, OSHA must show the following:

- There is a recognized hazard. On this, there is considerable case law, and while OSHA generally need not prove that the employer recognized the hazard, it is still necessary to show that the hazard has been recognized by industry or safety experts (14).
- The hazard is likely to cause death or serious physical harm.
- Feasible methods of abatement of the hazard exist.

The general duty clause is usually not applicable where a standard covering the hazard involved already exists, even when it can be shown that the existing standard is generally recognized as inadequate.

Employer obligations under the general duty clause are established on a case-by-case basis. This means that employers would have to sift through OSHA announcements and Occupational Safety and Health Review Commission and court decisions to determine what work schedule requirements are considered by OSHA to be recognized as a possible hazard. OSHA would have to establish, and reestablish, the recognition of these hazards in each individual case to be enforced. **Thus, use of the general duty clause to regulate work schedule hazards would probably lead to less effective compliance and would be more burdensome for the agency. In short, if OSHA decides to regulate employee work schedules, the requirements should be defined by a standard issued after rulemaking.** Despite the possible length of the standards proceedings, standards afford the only reliable basis for regulation. Until a standard is issued, the general duty clause would be available to deal with particularly egregious hazards (12).

State Plans

The OSH Act contains specific provisions dealing with State plans (29 U.S.C. 667). State occupational safety and health enforcement is expressly preempted by OSHA standards on the same issue, unless a State plan is in effect. States may submit their own programs for State occupational safety and health enforcement and, if found at least as effective as Federal standards, the State program will be approved. On approval, the State is entitled to escape preemption and to enforce its own program with 50 percent financial assistance from OSHA. Ultimately, a State may be granted final approval, at which time Federal enforcement legally ends and the State alone enforces safety and health obligations; however, the State must maintain its program at a level at least as effective as OHSA's. It also would be required to issue at least as effective a standard if OSHA were to promulgate a new standard for work schedules. OSHA continues to monitor the effectiveness of State programs, even after final approval, and may withdraw approval of a State plan [29 U.S.C. 667(f)].

There are at present 26 approved plans submitted by States and other jurisdictions, and 14 of these have been granted final approval. In these, there is no Federal enforcement, with States having jurisdiction over most occupational safety and health enforcement under their plans.

In sum, if OSHA undertook regulation of work schedules, the Federal standard and enforcement would cover fewer than half the States; the remainder would be covered by State standards and enforcement. This State activity must be at least as effective as OSHA's and, with limited exceptions, may be more effective [29 U.S.C. 667(c)(2)].

Mine Occupational Safety and Health

In 1977, Congress enacted the Federal Mine Safety and Health Act (30 U.S.C. 801 *et seq.*). This statute assigned enforcement of its standards to the Mine Safety and Health Administration (MSHA) in the Department of Labor. The act covers all coal and other mines and authorizes the issuance of mine safety and health standards (30 U.S.C. 803). The procedures for issuance of standards are similar to the OSHA procedure, including authority to issue emergency temporary standards (30 U.S.C. 811). MSHA is required to enforce these standards, but in a number of respects its enforcement provisions are more stringent than those in the OSH Act. Thus, for example, MSHA in some circumstances has administrative close-down authority (30 U.S.C. 817), and the mine safety statute provides for a mandatory minimum number of inspections per year for various kinds of mines (30 U.S.C. 813). The Supreme Court has held that, unlike OSHA, MSHA is not obligated to obtain a search warrant before conducting a mine inspection (6). The greater stringency of MSHA statutory procedures is due largely to congressional recognition of the seriousness and immediacy of hazards at mines.

The act does not provide for State plans, but State standards that provide for more stringent protection than Federal standards or provide protection where no applicable Federal standard exists may be enforced (30 U.S.C. 955). Provisions are also made for Federal grants to States for the purpose of developing and enforcing effective mine safety and health standards (30 U.S.C. 953).

MSHA is given explicit authority to issue mandatory health and safety standards for the protection of life and the prevention of injury in coal and other mines [30 U.S.C. 811(a)]. This authority parallels OSHA's authority, and on a satisfactory showing that work schedules create safety and health hazards for employees, MSHA would have authority to issue mandatory standards protecting employees from work schedule hazards (12).

OSHA is preempted by the OSH Act from applying to any working condition covered by another statutory program [29 U.S.C. 653(b)(1)]. Since mine employees are covered comprehensively by MSHA standards and enforcement, OSHA does not apply to them or to mine working conditions.

Other Safety and Health Statutes

In addition to statutes dealing with protection of employees, there are mixed-purpose statutes designed to protect both public and employee safety. An example is the Federal Railroad Safety Act of 1970 (45 U.S.C. 421 *et seq.*), designed to protect both railroad employees and passengers and members of the public who may be affected by railroad operations.

Federal Railroad Safety Act

The Federal Railroad Safety Act is designed to:

- promote safety in all areas of railroad operations;
- reduce railroad-related accidents; and
- reduce deaths and injuries to persons caused by accidents involving any carrier of hazardous materials (45 U.S.C. 421).

Under the law, the Secretary of Transportation, acting through the Federal Railroad Administration, is required to prescribe rules, regulations, orders, and standards for all areas of railroad safety, supplementing those laws and regulations already in effect (45 U.S.C. 431). The statute expressly provides that FRA is not authorized to issue rules related to qualifications of employees except when qualifications are specifically related to safety [45 U.S.C. 431(a)]. The act further authorizes carriers and unions to enter into bargaining agreements related to qualifications of employees, consistent with FRA rules issued under the statute. The statute contains a timetable for FRA issuance of safety rules and provides for court review of the rules.

The act authorizes railroad safety rules to supplement those contained in earlier statutes and in previously issued administrative rules. Thus, while the Hours of Service Act (45 U.S.C. 61 *et seq.*) prescribes specific limitations on the hours of service of specific categories of railroad employees, the Railroad Safety Act would authorize FRA to issue safety rules for additional categories of railroad employees or prescribe additional requirements. These new rules could impose limitations on employee work schedules as long as the rules were specifically related to safety.

FRA has promulgated regulations on the control of alcohol and drug use by railroad employees to prevent accidents and casualties resulting from impairment of employees (49 CFR 219). Accordingly, it could be argued that FRA would have authority to regulate work schedules if it could be proved that regulation would prevent railroad accidents resulting from such conditions as fatigue and inattention.

Motor Carrier Safety Act

Under the MCSA, the Secretary of Transportation is authorized to issue regulations establishing minimum Federal safety standards for commercial motor vehicles. At a minimum, these standards must ensure that:

- the responsibilities imposed on operators of vehicles do not impair their ability to operate the vehicles safely;
- the physical condition of operators is adequate to enable them to operate vehicles safely; and
- the operation of vehicles does not have deleterious effects on the physical condition of operators (49 U.S. App. 2505).

This authority is broad enough to include work schedule regulation. Indeed, FHWA has already issued hours of service regulations and regulations on alcohol and drug use of operators, which have been upheld (22). Accordingly, FHWA could amend existing hours of service regulations or issue additional regulations on work scheduling.

Federal Aviation Act

Under this statute, the FAA has specific authority, in the interests of safety, to issue reasonable rules and regulations governing the maximum hours or periods of service of airmen and other employees of air carriers. The FAA is also authorized to issue reasonable rules and regulations or minimum standards governing other practices, methods, and procedures it finds necessary to provide adequately for safety in air commerce [49 U.S.C. App. 1421(a)(5),(6)]. As already discussed, FAA has issued hours of service regulations for various categories of employees in air commerce, and it would have the authority to modify or add to these regulations, subject to court review.

U.S. Coast Guard

The Coast Guard supervises the merchant marine of the United States and merchant marine personnel. It has specific statutory authority to take action governing vessels and shipping in the interests of marine safety and seamen's welfare (46 U.S.C. 2103). The statute also contains specific requirements for the manning of vessels, including limitations on hours of service for certain types of employees, particularly in relation to watches on ships. The Coast Guard has general authority to issue interpretations of the manning requirements (46 CFR 15) and hours limitations and to issue regulations limiting hours beyond those stipulated by the statute, based on its authority to regulate marine safety and seamen's welfare.

Energy Reorganization and Development Act

The NRC has authority to issue regulations governing nuclear materials in order to protect health or to minimize danger to life or property [42 U.S.C. 2201(b)]. This could provide sufficient authority for the agency to regulate work schedules of covered employees. NRC has already issued regulations related to fitness for duty of employees of licensees, prescribing a program of drug and alcohol testing (10 CFR 26). Work schedule regulations could be analogous, as they, too, impose requirements for fitness for duty. The relevance of schedule restrictions to fitness has been recognized explicitly by NRC in a policy statement.

Relationship of OSHA to Other Laws

Broadly speaking, where an agency has general statutory authority to regulate employee safety or health, or both, this authority ordinarily includes regulation of work schedules if the connection between safety and health and the regulatory requirements can be shown. There may be more limited authority over work schedules under specific statutes, and conclusions on the extent of that authority can be drawn from the statutory language, its legislative history, and relevant decisions. The OSH Act covers occupational safety and health in all private industries. In addition, there are other statutes which provide regulatory authority over both public and occupational safety and health; these include several statutes administered by the Secretary of Transportation (45 U.S.C. 2121; 49 U.S.C. App. 1421). These statutes may also provide agency authority over work schedules of employees.

There remains the issue of the jurisdictional overlap between OSHA's broad employee safety and health coverage and the coverage of industry-specific statutes relating to employee safety and health. Thus, for example, employees of private railroads are covered by OSHA under the Railroad Safety Act and the Hours of Service Act. The OSH Act [29 U.S.C. 653(b)(1)] deals with this issue and provides that the act does not apply to working conditions when other Federal agencies exercise statutory authority to prescribe or enforce standards or regulations affecting occupational safety and health. While the language of this section is not entirely clear, its purpose is to prevent redundant regulation of occupational safety and health, while avoiding any gaps in employee protection. OSHA has issued an interpretative regulation of this provision (29 CFR 1955), which contains the following general principles:

- The act applies only when *specific working conditions* are regulated by another Federal agency. OSHA would not be preempted in an entire industry merely because some working conditions in that industry were regulated by another Federal agency (20). The only industry-wide preemption that has taken place is in mining, which is regulated comprehensively under the Mine Safety and Health Act.
- The regulation of working conditions by another Federal agency would be preemptive, even where the relevant statute is not directed exclusively to employee safety and health (for example the Railroad Safety Act, which also deals with public safety). However, the statute must intend to include employees in the class of persons to be protected under it (7).
- In order to preempt OSHA, another Federal agency must have exercised its statutory authority to protect employees (19).

It is apparent, therefore, that it would be necessary to study the statutes and regulations of both OSHA and other Federal agencies to determine, in the event of overlapping jurisdiction, which regulations would apply. Even after study, the answer may not be apparent, and court decisions sometimes add to the confusion. In order to clarify jurisdictional issues for the public and the agencies themselves, OSHA has entered into a series of agreements with other

Federal agencies to define more accurately their respective jurisdictions.

Fair Labor Standards Act

As discussed, the child labor provisions of FLSA authorize the Department of Labor's Wage and Hour Division to issue regulations respecting the employment of children 14 to 16 years old to ensure that their employment in permissible occupations will not interfere with their schooling or their health and well-being [29 U.S.C. 203(l)(2)]. The Wage and Hour Division has issued such regulations (29 CFR 570.35) and has authority to amend or replace them, but it does not appear to have authority to regulate the *hours of employment* of other minors. Thus, FLSA prohibits the employment of children 16 to 18 years old in an occupation which the Division determines is particularly hazardous and detrimental to their health and well-being [29 CFR 570(E)]. The Division's discretion, therefore, relates to defining the particularly hazardous *occupations* and not to determining permitted hours of employment [29 CFR 570(E)]. For children under 14, the statute bars any employment [29 U.S.C. 203(l)] except under specific circumstances in agriculture and the entertainment industry [29 U.S.C. 213(c)].

The overtime provisions of FLSA would not provide authority for direct regulation of shift schedules. Under the act, an employer is prohibited from employing workers for more than 40 hours a week unless a premium wage is paid. It follows that if the appropriate time-and-a-half wage rates are paid, there would be no barrier to employment under FLSA for hours beyond the 40-hour week in any arrangement that is otherwise in accordance with law. This conclusion is underscored by a consideration of the main purpose of the overtime provisions of FLSA, which was to spread the work among more workers. While the law had an additional purpose, namely, to promote health among workers by limiting excessive work hours and thus providing for more rest and leisure, this further goal was achieved by providing a financial penalty for employers who imposed lengthy hours on the existing work force. Any argument that FLSA authority extends to direct shift regulation could persuasively be answered by citing the OSH Act, passed 22 years after FLSA, which was designed expressly to protect employee health and which provides clear authority for direct shift regulation. On the other hand, the Wage and Hour Division would have authority to modify its interpretations of hours worked and thus indirectly affect work schedules.

Labor Relations Statutes

So far, this chapter has considered shift regulation under command and control type regulatory statutes, which impose direct and enforceable obligations on employers. The Labor-Management Relations Act (LMRA), originally enacted as the National Labor Relations Act in 1935, amended and renamed in 1947, and amended twice since then, provides a regulatory framework for employee exercise of collective rights, including the right to bargain collectively and to enter into collective bargaining agreements (29 U.S.C. 141 *et seq*.). These bargaining agreements may, and often do, contain provisions on limitations of hours and shift restrictions, which are enforceable as a matter of contract law through private remedies.

Labor-Management Relations Act

The LMRA is administered by a five-member National Labor Relations Board (29 U.S.C. 153). The coverage of the act is broad, applying to virtually all private employers (29 U.S.C. 152).

Under the act, the employer and the union are obligated to bargain collectively with each other, and a refusal to bargain in good faith is an unfair labor practice [29 U.S.C. 158(a)(5),(b)(3),(d)]. The obligation to bargain in good faith relates only to mandatory subjects of bargaining, that is, wages, hours, and other terms and conditions of employment (13). There is a considerable body of case law on the issue of what subjects are mandatory, but there is little doubt that hours of employment, including work schedules, are among them.

The LMRA does not regulate shift schedule limitations directly. However, at least partly because of the legal requirements imposed by the act, parties regularly enter into collective bargaining agreements that include hours and shifts. Bargaining agreements with such clauses may be reached voluntarily by parties not covered by LMRA.

While LMRA covers the bulk of private employees, several other labor-management statutes should be mentioned. The Railway Labor Act (45 U.S.C. 151 *et seq*.) governs the labor relations of railroads and their employees. Like LMRA, the Railway Labor Act requires carriers and employees to exert every reasonable effort to make and maintain agreements (45 U.S.C. 152). This obligation covers rates of pay, rules, and working conditions. While hours are not expressly mentioned, the obligation to bargain over them could be encompassed by working conditions.

There is a wide range of clauses in collective bargaining agreements relating to hours of work. These have been collected in the Bureau of National Affairs' *Collective Bargaining, Negotiation and Contracts* (5). According to this survey, virtually all contracts contain hours and overtime provisions; typical provisions include:

- daily and weekly work schedules;
- overtime premium pay;
- distribution of overtime work; and
- length of lunch and rest periods (5).

Many contracts state the length of the workday and workweek, and some specify the days of the week on which work may be performed. Management, however, may retain scheduling rights, frequently with a requirement for advance consultation with the union (5).

Some contracts provide specific restrictions on scheduling, such as no split shifts (5) and limits on switching employees from one shift to another (5). The bargaining agreement between a steel company and a chemical workers' union (5) provides that employees are not permitted to work more than 16 hours within any 24-hour period unless an employee is awaiting replacement and is willing to stay or needs 2 additional hours to finish a job.

Various contract clauses deal with overtime, covering both scheduling and premium compensation. One contract for aluminum and steel workers (5) limits the amount of employee overtime. Except in cases of emergency, no employee may be permitted or required to work:

- more than 16 consecutive hours in a workday;
- 16 overtime hours in a workweek;
- more than two consecutive 16-hour work periods; or
- more than 16 hours in any 24-hour period.

In another contract for industrial workers, no employee may be required to work more than 12 continuous hours and may not be penalized for leaving after that time (5). Other provisions relate to rest periods with pay during regular shifts (5).

In sum, there are many clauses concerning shift scheduling that may appropriately be part of the mandatory collective bargaining process.

State Labor Relations Legislation

A number of States have labor relations statutes addressing mandatory bargaining issues. For example, the Connecticut Labor Relations Act (Conn. Gen. Stat., 1958 rev. sec. 31-101-111, *CCH Rep.*, 47,000) contains:

- provisions defining the rights of employees (sec. 31-104);
- provisions prohibiting unfair labor practices by employers (sec. 31-105);
- procedures for employee election of representatives (sec. 31-106); and
- procedures for the handling of unfair labor practices cases (sec. 31-107).

In some cases, State labor relations statutes are applicable only to a specific industry, for example, the California Agricultural Labor Relations Act (Third Extraordinary Sess., L. 1975, amended, ch. 1292, L. 1980; *CCH Rep.*, 47,400). In any event, the scope of these labor relations laws depends both on their language and interpretation and, significantly, on the extent to which they are preempted by the Federal LMRA.

Federal preemption in the field of labor relations has been much litigated and has been the subject of numerous Supreme Court decisions. The purpose of Federal preemption is to avoid duplicative or inconsistent State regulation of conduct regulated by the Federal Government under the U.S. Constitution's supremacy clause. Preemption depends in the first instance on the intent of Congress as expressed in the Federal statute. In the case of LMRA, Congress expressly provides that the States are free to regulate with respect to employers over whom the National Labor Relations Board lacks legal jurisdiction or declines to exercise its jurisdiction [29 U.S.C. 164(c)]. Otherwise, since Congress has not indicated its intention to preempt State regulation completely, the courts must decide the extent of the preemption.

The Supreme Court has developed three tests for deciding whether State regulation is preempted in the field of labor relations (1, 10, 18). Early in the history of the LMRA, the Supreme Court applied the tests quite strictly, often finding State regulations preempted (18). More recently, the Court has found preemption inapplicable, for a variety of reasons (4).

The important point here is that State regulation of labor relations cannot be considered separately from the Federal requirements and the preemptive effect of the Federal regulatory structure (9).

GOVERNMENT EMPLOYEES

The government as employer determines the working conditions of its employees. Its authority may be limited by certain authorizing statutes or by other regulatory statutes insofar as they apply to government employees, for example, FLSA. In addition, both the Federal and many State governments may have bargaining obligations under labor relations statutes specifically applicable to government employees.

Federal Employees

Under Federal law, each executive agency is required to establish a basic administrative workweek of 40 hours for full-time employees and to require that work be performed within a period of not more than 6 of any 7 consecutive days [5 U.S.C. 6101(a)(2)]. The law further imposes certain limitations on work scheduling, except in cases where the agency head determines that agency operations would be seriously handicapped or costs would be substantially increased by them. These limitations are:

- assignments to tours of duty are scheduled in advance, over periods of not less than 1 week;
- the basic workweek is scheduled on 5 days, Monday through Friday when possible, and the 2 days outside the basic workweek are consecutive;
- the working hours in each day in the basic workweek are the same;
- the basic nonovertime workday does not exceed 8 hours;
- the occurrence of workdays does not affect the basic workweek; and
- breaks of more than 1 hour may not be scheduled in a basic workday [5 U.S.C. 6101 (a)(3)].

An important innovation in Federal employee work scheduling took place with enactment of legislation providing for flexible and compressed work schedules for Federal employees. This law was originally passed in 1978 [Public Law 95-390 (1978)] and amended several times, most recently in 1982 [Public Law 97-221 (1982); 5 U.S.C. 6121 *et seq.*]. Under the statute presently in effect, an agency is authorized to establish programs of flexible schedules, which include:

- designated hours during which an employee must be present for work; and
- designated hours which an employee may elect as the time for his or her arrival or departure, solely . . . for the purpose of accumulating credit hours to reduce the length of the workweek or another workday [5 U.S.C. 6122(a)].

The head of an agency may cancel all or part of a flexible scheduling program if he or she determines that the program is substantially disrupting agency operations or is incurring additional costs [5 U.S.C. 6122(b), 6131].

The statute also authorizes an agency to establish programs which use a 4-day workweek or other compressed schedules (5 U.S.C. 6127). It provides for excepting an employee from a compressed schedule program or transferring the employee if the program imposes personal hardship. In addition, the head of an agency may decide not to establish or to discontinue a flexible or compressed schedule if it would have an adverse impact on the agency, as defined in the statute [5 U.S.C. 6131(a)].

The OSH Act does not apply directly to Federal and State employees [29 U.S.C. 652(5)]; therefore, OSHA standards and the statute's enforcement provisions are not used by the Department of Labor to enforce safety and health requirements in the Federal workplace. However, the OSH Act contains a separate provision, section 19 (29 U.S.C. 668), covering safety and health programs for Federal agencies. The section assigns to the head of each Federal agency the responsibility for establishing and maintaining an effective and comprehensive safety and health program that is consistent with the standards promulgated by OSHA covering private employees [29 U.S.C. 668(a)]. If OSHA issues requirements for private employers concerning safety and health (as, for example, limitations on hours of work), the heads of the Federal agencies would be required to impose similar limitations, except to the extent that circumstances differ, as determined by OSHA.

The FLSA applies to most Federal Government employees, including civilians in the military and employees of the executive, judicial, and legislative branches of the Federal Government [29 U.S.C.

203(e)]. Thus, the wages, hours, and working conditions set by the Federal Government for Federal employees must meet the minimum wage, overtime, and child labor requirements of the FLSA.

In 1966, Congress passed the Federal Labor-Management Relations Act (5 U.S.C. 7101 *et seq.*), establishing a program of labor relations for Federal employees. The program is administered by the Federal Labor Relations Authority (5 U.S.C. 7104). The basic rights of employees include the right to join or assist a union, or to refrain from such activity, and through their own representatives to engage in collective bargaining with respect to conditions of employment (5 U.S.C. 7102). However, because the Federal Government is the employer, and because Federal employees may not strike to enforce their demands (5 U.S.C. 1819), the obligation of the Federal agency to bargain with Federal employee unions is defined in a more limited manner than the bargaining obligation of private employers (5 U.S.C. 7106, 7117). For example, with certain exceptions, the agency's obligation to bargain collectively must be consistent with any Federal law or any Government rule or regulation [5 U.S.C. 7117(a)(1), (2)]. A Federal agency's authority to fix hours of work for its employees may be affected by its statutory bargaining obligation. Many bargaining agreements between Federal agencies and Federal employee unions are in effect, and some contain provisions on hours of work of Federal employees.

State Employees

State governments and their agencies are authorized to set the hours and working conditions of State employees in accordance with the provisions of State law. State law is applicable to the extent that it is not preempted by Federal law and does not contravene any specific constitutional prohibition or statutory prohibitions in Federal or State law.

The OSH Act does not cover State employees [29 U.S.C. 652(5)]. However, in order for a State to qualify for Federal approval or financial assistance, its employees must be covered by an occupational safety and health plan that is as effective as the plan covering private employees [29 U.S.C. 667(c)]. In addition, OSHA regulations allow States to develop and obtain approval for plans covering State employees alone. Under these laws and regulations, if the OSH Act were to limit the hours and shifts of employees, States with approved plans would be required to do likewise for both private and State employees.

The FLSA currently applies, with some exceptions, to State and local employees [29 U.S.C. 203(e)(2)(C)]. While the child labor provisions apply without change to State employees, FLSA now allows States to grant compensatory time instead of overtime pay under some circumstances for State employees [29 U.S.C. 207(o)]. In addition, FLSA contains provisions directed specifically toward employees engaged in fire protection and law enforcement activities for State public agencies [29 U.S.C. 207(K)].

The LMRA does not apply to State employees [29 U.S.C. 152(2)]. However, a number of States have their own labor relations statutes governing State and local employees, and these statutes impose collective bargaining obligations on the parties. An example is the Massachusetts State labor relations act, which includes a requirement that the State bargain with employee representatives *(CCH Labor Law Rep.*, Massachusetts 47,000). However, because the State is the employer, the bargaining obligation is defined more narrowly than under the LMRA, which is applicable to private employees (*CCH Rep.*, 47,019, 47,025).

SUMMARY AND CONCLUSIONS

The protection of the safety and health of American working men and women is the central goal of a variety of Federal and State regulatory statutes. The best known of these is the Federal Occupational Safety and Health Act.

Since early in 20th century, the protection of employees and the public from the hazards resulting from certain work scheduling practices in the transportation industry has been the subject of specific regulatory action. At present, enforceable statutes or regulations are applicable to various groups of railroad, motor carrier, air carrier, and maritime employees. In addition, the Federal minimum wage law limits the working hours of certain minors.

Under the Federal Labor-Management Relations Act, employees are guaranteed the right to organize and to bargain collectively. Additional protection against the hazards to employees of work scheduling is also afforded under a number of voluntarily negotiated collective bargaining agreements.

States provide parallel protection to employees against work scheduling risks under statutes and regulations, subject, however, to the limitations imposed by the doctrine of Federal preemption.

In general, currently effective Federal and State statutes provide a broad base of authority for the issuance and implementation of regulations to strengthen the protection of employees in this area. Particularly noteworthy in this regard is the OSH Act, with its pervasive coverage of all private employers. Acting under this statute, the Department of Labor has authority, on a showing of significant risk to employees, to issue and enforce regulations relating to work scheduling. States with approved occupational safety and health plans would be required to provide protection that is at least as effective as that under the OSH Act.

While no additional statutory authority is necessary to enhance employee protection, it should be recognized that the enactment of an industrywide statute dealing expressly with the regulation of work scheduling would constitute a strong declaration of governmental policy and would provide a considerable impetus to protective progress in this area.

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Chapter 7

Case Study: Nuclear Powerplant Control Room Operators

In March 1987, the U.S. Nuclear Regulatory Commission (NRC) was notified that several control room operators at the Peach Bottom atomic power station had been found sleeping while on the job and not performing their duties; 7 days later, the NRC shut down the Peach Bottom powerplant, marking the first time the NRC had ordered a plant shut down for operator deficiencies. The NRC found:

- At times during various shifts, particularly during the 11 p.m. to 7 a.m. shift, one or more of the operations control room staff (including licensed operators, senior licensed operators, and shift supervisors) periodically slept or had been otherwise inattentive to licensed duties while on shift during at least the past 5 months.
- Management at the shift supervisor and shift superintendent levels either knew about and condoned the facts set forth above or as a part of their duties should have known of these facts and taken action to correct the situation.
- Plant management above the shift superintendent position either knew about and condoned the facts set forth above or should have known the facts and taken action to correct this situation (18).

The Peach Bottom nuclear powerplant reopened in April 1989, after a costly, 2-year shutdown. What occurred at Peach Bottom was a situation in which a breakdown in management, combined with disruptions of circadian rhythms and fatigue effects, created conditions in which the safe operation of the plant was jeopardized. In particular, lack of management oversight during the night shift (11 p.m. to 7 a.m.), when performance and alertness decrements are most likely, resulted in the behavior observed by the NRC. Though no accident resulted from operator inattentiveness at Peach Bottom, other accidents and incidents, such as that at Three Mile Island in 1979, have occurred during these hours of operation.

This case study examines the job of nuclear powerplant control room operators, a job characterized by continuous, routine monitoring tasks that must be carried out 24 hours a day, usually on a rotating shift schedule. It is an example of an occupation in which the adverse effects that can result from shift work may have negative implications not only for the worker, but for the public as well.

WHO ARE THE WORKERS?

According to the NRC, there were 111 nuclear power reactors licensed for operation by the Commission in the United States in 1989. Five additional reactors are scheduled to be completed by 1995 (21). The NRC has estimated that there are 5,290 licensed control room operators in the United States, consisting of 1,969 licensed reactor operators and 3,321 senior reactor operators.

Nuclear power operator trainees come from three primary sources: 1) fossil fuel powerplant personnel; 2) U.S. Navy nuclear programs; and 3) interested young people, typically possessing a high school education, starting a career. Training for the novice is carried out by individual utility companies and consists of many months of classroom work on the necessary theories, skills, and knowledge required to operate a facility. This process may be partially waived for persons with equivalent training (e.g., former operators at another facility or persons trained in reactor operations by the Navy). Some experience credit is given to individuals who have worked at fossil fuel plants. Subsequent training consists of actual experience at various nonlicensed operator positions, which familiarizes the trainee with the equipment and control system characteristics. Operators also train on high-fidelity simulators.

The NRC licensing examiners conduct plant-specific oral, written, and simulator examinations of the trainees to ensure that candidates are prepared for, and capable of, performing the tasks of a nuclear reactor operator or of supervising the powerplant control room operations as a senior reactor operator. Continuing training throughout the operator's career is provided by the utility companies through their programs for maintaining and upgrading personnel skills. It takes up to 6 years to complete the training program. Individuals with previous related experience may require 3 years' training. Operators' licenses are renewed every 6 years through NRC testing.

WORKING HOURS AND OVERTIME

NRC Oversight

All nuclear powerplants must be licensed by the NRC. The licenses are legally binding and place numerous conditions on nuclear reactor design, construction, and operations. Part of the licensing process is the implementation of a plant's technical specifications, which describe all aspects of that plant's operations. Besides the licensing process, the NRC has authority to issue policy statements or promulgate regulations related to the operation of nuclear powerplants. NRC policy statements "urge or strongly recommend" that a nuclear powerplant follow a given course (7). **The NRC's policy statements are not enforceable per se, and a plant is not required to incorporate them into its technical specifications and administrative procedures. However, if a plant does incorporate NRC policy statements into its technical specifications or administrative procedures, the plant must follow that policy.** The NRC may then issue notices of violations of the technical specifications (7).

Powerplants must comply with NRC regulations. In response to violations of regulations, the NRC may require a plant to change its administrative procedures, perform operations differently, enforce standard operating procedures, or change its design. In cases of repeated violations or failure to comply with NRC directives, the NRC may shut down a facility.

The NRC's resident inspectors are its primary means of monitoring compliance with regulations. These inspectors are assigned to all nuclear powerplants to ensure: 1) that the facility is being operated safely and in conformance with licensing and regulatory requirements, and 2) that the licensee's management is effectively discharging its responsibilities for continued safe operation (24).

Guidelines for the NRC and OSHA

Responsibility for safety and health at nuclear powerplants is divided between the Occupational Safety and Health Administration (OSHA), within the U.S. Department of Labor, and the NRC. OSHA has regulatory jurisdiction for health and safety matters in the workplace, including nuclear powerplants. The NRC, on the other hand, has regulatory oversight of the operations of all utilities licensed to operate by the Commission. In October 1988, in an effort to clarify and coordinate the roles of these two Federal agencies, OSHA and the NRC collaborated on a memorandum of understanding to provide general guidelines regarding worker protection at NRC-licensed facilities (53 FR 43950-43952). The memorandum specifically defines the roles and responsibilities of each agency for achieving worker safety and health at NRC-licensed plants. For example, OSHA investigates worker injuries at nuclear powerplants, as it does for other industries, while the NRC is responsible for regulating hours of work. This memorandum also provides general procedures for the coordination of activities and exchange of information between the two agencies.

The NRC and Shift Schedules

Currently, there are no NRC regulations specifically covering shift scheduling or working hours for nuclear powerplant operators; however, there are NRC policy statements regarding total working hours for operators. Shift schedules at nuclear powerplants are implemented by the plant management and are sometimes the result of management-labor negotiations. Control room operators can work several types of shift schedules. Many work an 8-hour-per-day shift schedule; however, more powerplants are switching to a 12-hour-per-day schedule (2).

The development of policies on work schedules for control room operators is relatively new. The NRC published its first policy on overtime and working hours in a letter in July 1980 (13). In November 1980, the NRC revised this policy to make it more flexible (14), and in 1982, additional revisions provided further clarification and established a formal policy statement, which was transmitted in Generic Letter 82-12 (15) and Generic Letter 82-16 (16) (47 FR 7353). **The Generic Letters provide guidance on how to implement the policy statements on shift scheduling and working hours for nuclear powerplant control room operators.** They consist of the following guidelines:

- An individual should not be permitted to work more than 16 consecutive hours (excluding shift turnover time).
- An individual should not be permitted to work more than 16 hours in any 24-hour period, more

than 24 hours in any 48-hour period, or more than 72 hours in any 7-day period (all excluding shift turnover time).

- A break of at least 8 hours should be allowed between work periods (including shift turnover time).
- The use of overtime should be considered on an individual basis, not for the entire staff on a shift.

In addition to these guidelines, the NRC urged that licensed operators be periodically relieved and assigned to duties away from the control board, in order to reduce fatigue during a shift (47 FR 7353). The NRC policy statement embodied in the Generic Letters indicates that all nuclear powerplants should establish controls to prevent situations in which fatigue could reduce the ability of control room operators to run the reactor safely. Thus, workers should not be assigned to shift duties while in a fatigued condition, because fatigue could significantly reduce their alertness and decisionmaking capabilities.

The NRC recommends that plants hire enough staff to work shift hours without continuous, burdensome use of overtime and that workers routinely work an 8-hour day and 40-hour week while the plant is in operation. The NRC policy statement also applies to situations in which the operations of the facility require overtime or the plant has been shut down for refueling, major maintenance, or major modifications. To date, approximately 77 of the 111 licensed nuclear powerplants have incorporated these policy statements into their technical specifications.

8-Hour-per-Day Shift Schedules

In 1985 the NRC contracted with a private laboratory to set up an expert panel to study NRC policy related to scheduling (17). The panel's recommendations for a routine 8-hour-per-day shift schedule consist of various suggestions designed to reduce excessive working hours, including:

- limiting the schedule to a maximum of 7 consecutive days of work,
- maintaining a schedule that does not exceed 21 days of work (including training) in any 4-week period,
- ensuring that the schedule includes at least 2 consecutive full days off in any period of 9 consecutive days,
- ensuring at least 2 full days of rest following night shifts, and
- rotating the schedule forward, not backward.

To date, these recommendations are still under review by the NRC.

Features of 8-Hour Schedules

Most plants use rotating shifts to apportion the more desirable morning and afternoon shifts and the least favored night shifts equally among all staff members (5). However, there are other reasons for using a rotating shift system. First, locating people willing to work on a permanent night shift is often difficult; second, when seniority governs the choice of which shift is to be worked (as often occurs in permanent shift systems), the older, most experienced people usually opt for day work; and third, the precedent for rotating shifts was set at fossil fuel powerplants.

Control room operators typically rotate through three 8-hour shifts (5):

- a morning shift (usually 8 a.m. to 4 p.m.),
- an afternoon shift (usually 4 p.m. to midnight), and
- a night shift (usually midnight to 8 a.m.).

Continuous three-shift systems usually have four, five, or six crews of workers in order to have workers on duty over weekends and still provide rest periods. Most nuclear powerplants operate with six crews. The Institute of Nuclear Power Operations conducted a survey in 1989 on the number of operating crews commonly used. Of the 75 plants surveyed, 50 reported that they were using six crews. The remaining 25 plants operated with five crews, but two of these indicated that they were preparing to change to a six-crew operations system (4).

As described in chapters 4 and 5, 8-hour shift schedules can vary in their direction and speed of rotation. As in other work settings, many types of schedules are used at nuclear powerplants, although weekly rotating schedules are typical. Figure 7-1 is one example of an 8-hour shift schedule.

12-Hour-per-Day Shift Schedules

Within the last few years, 12-hour work schedules have become more popular in nuclear powerplants. Twenty-three plants now operate under 12-hour schedules (25). If a plant has incorporated its shift schedules into its technical specifications and ad-

Figure 7-1—Example of an 8-Hour-per-Day Work Schedule Used in the Nuclear Power Industry

Day of the week	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S
Crew A	D	D	D	D	D	-	-	-	-	A	A	A	A	A	A	A	-	-	T	D	D	T	T	T	-	N	N	N	N	N	N	N	-	-	-
Crew B	N	N	N	N	-	-	-	D	D	D	D	D	-	-	-	-	A	A	A	A	A	A	A	-	-	T	D	D	T	T	T	-	N	N	N
Crew C	T	T	T	-	N	N	N	N	N	N	N	-	-	-	D	D	D	D	D	-	-	-	-	A	A	A	A	A	A	A	-	-	T	D	D
Crew D	A	A	-	-	T	D	D	T	T	T	-	N	N	N	N	N	N	N	-	-	-	D	D	D	D	D	-	-	-	-	A	A	A	A	A
Crew E	-	-	A	A	A	A	A	A	A	-	-	T	D	D	T	T	T	-	N	N	N	N	N	N	N	-	-	-	D	D	D	D	D	-	-

The work/training schedule for five crews (A,B,C,D,E) over a 5-week period is illustrated.
KEY: D= day shift; A= afternoon shift; N= night shift; T= training; — = day off.

SOURCE: U.S. Nuclear Regulatory Commission, *NUREG/CR-4248, Recommendations for NRC Policy on Shift Scheduling and Overtime at Nuclear Power Plants* (Richland, WA: Pacific Northwest Laboratory, 1985).

ministrative procedures, it must first get NRC approval before implementing a 12-hour schedule; if it has not, NRC notification is not required. Currently there is no NRC guidance regarding the implementation of 12-hour schedules. The expert panel on scheduling, described earlier, also developed the following guidelines for 12-hour work schedules (17):

- Adoption of a routine 12-hour-per-day schedule must be authorized by the NRC.
- The schedule should contain a maximum of 4 consecutive 12-hour workdays.
- Four consecutive 12-hour workdays should be followed by no fewer than 4 days off.
- The basic 12-hour-per-day schedule could be one of several types: 2 days on, 2 days off; 3 days on, 3 days off; 4 days on, 4 days off. Another possible schedule would be the every-other-weekend-off schedule, which combines 2 days on, 2 days off with 3 days on, 3 days off.
- The general safety record of the plant should be satisfactory, based on criteria such as those used in NRC's Systematic Assessment of Licensee Performance ratings.
- The plant should have the capability to cover unexpected absences satisfactorily without requiring any individual to work more than 12 hours per day.
- The round trip commute times for the operators should not exceed $2^1/2$ hours.

Features of 12-Hour Schedules

A number of 12-hour work schedules are in use at present. An advantage of these schedules is that the worker has more nonworking days during the week, thus allowing more time for rest and leisure. A potential drawback is that the 4 additional hours per shift may produce fatigue and decrements in alertness (2,9-11).

Typically there are three types of 12-hour shift schedules (8,12):

1. every other weekend off (EOWEO);
2. 3 days on, 3 days off rotating schedule; and
3. 4 days on, 4 days off rotating schedule.

Figure 7-2—Example of an Every-Other-Weekend-Off 12-Hour Shift Schedule Used in the Nuclear Power Industry

Day of the week	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S
Nights	A	B	B	D	D	C	C	C	A	A	B	B	D	D	D	C	C	A	A	B	B	B	D	D	C	C	A	A
Days	D	C	C	A	A	B	B	B	D	D	C	C	A	A	A	B	B	D	D	C	C	C	A	A	B	B	D	D
Off	B	A	A	B	B	A	A	A	B	B	A	A	B	B	B	A	A	B	B	A	A	A	B	B	A	A	B	B
Off	C	D	D	C	C	D	D	D	C	C	D	D	C	C	C	D	D	C	C	D	D	D	C	C	D	D	C	C

The work schedule for four crews (A,B,C,D) over a 4-week period. For example, during week 1, crew A works Sunday night, has Monday and Tuesday off, works days Wednesday and Thursday, and then Friday and Saturday has off.

SOURCE: H.R. Northrup, J.T. Wilson, and K.M. Rose, "The Twelve-Hour Shift in the Petroleum and Chemical Industries," *Industrial and Labor Relations Review* 32:312-316, 1979.

Figure 7-3—Example of a 4-Days-On, 4-Days-Off Rotating Schedule Used in the Nuclear Power Industry

Day of the week	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S
Day	D	D	A	A	A	A	B	B	B	B	C	C	C	C	D	D	D	D	A	A	A	A	B	B	B	B	C	C
Night	B	B	C	C	C	C	D	D	D	D	A	A	A	A	B	B	B	B	C	C	C	C	D	D	D	D	A	A

Day of the week	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S
Day	C	C	D	D	D	D	A	A	A	A	B	B	B	B	C	C	C	C	D	D	D	D	A	A	A	A	B	B
Night	A	A	B	B	B	B	C	C	C	C	D	D	D	D	A	A	A	A	B	B	B	B	C	C	C	C	D	D

Day of the week	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S
Day	B	B	C	C	C	C	D	D	D	D	A	A	A	A	B	B	B	B	C	C	C	C	D	D	D	D	A	A
Night	D	D	A	A	A	A	B	B	B	B	C	C	C	C	D	D	D	D	A	A	A	A	B	B	B	B	C	C

Day of the week	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S
Day	A	A	B	B	B	B	C	C	C	C	D	D	D	D	A	A	A	A	B	B	B	B	C	C	C	C	D	D
Night	C	C	D	D	D	D	A	A	A	A	B	B	B	B	C	C	C	C	D	D	D	D	A	A	A	A	B	B

The work schedule for four crews (A,B,C,D) over a 16-week period. For example, crew A works the day shift on 4 consecutive days during week 1, has 4 days off, then works the night shift for 4 consecutive days before having another 4 days off.

SOURCE: H.R. Northrup, J.T. Wilson, and K.M. Rose, "The Twelve-Hour Shift in the Petroleum and Chemical Industries," *Industrial and Labor Relations Review* 32:312-316, 1979.

Figure 7-2 is an example of an EOWEO schedule, and figure 7-3 is an example of a 4 days on, 4 days off rotating schedule, both of which are commonly used for control room operators.

Overtime

Nuclear powerplants have used a variety of overtime schedules for operators. The NRC recommends, but does not require, that plants have an overtime policy. In 1988, 76 plants had a specific overtime policy written in their technical specifications; 32 plants did not (6). As described earlier, the 1982 Generic Letters provide guidance regarding the maximum number of hours of work for 24-hour, 48-hour, and 7-day periods. The expert panel on scheduling developed further guidelines for overtime scheduling (7), which include:

- The approval of the plant manager should be required before individuals are allowed to exceed the following limits: 60 hours of work in 7 days, 112 hours of work in 14 days, 192 hours of work in 28 days, and 2,260 hours of work in 1 year.
- NRC approval should be required before individuals are allowed to exceed the following limits: 72 hours of work in 7 days, 132 hours of work in 14 days, 228 hours of work in 28 days, and 2,300 hours of work in 1 year.

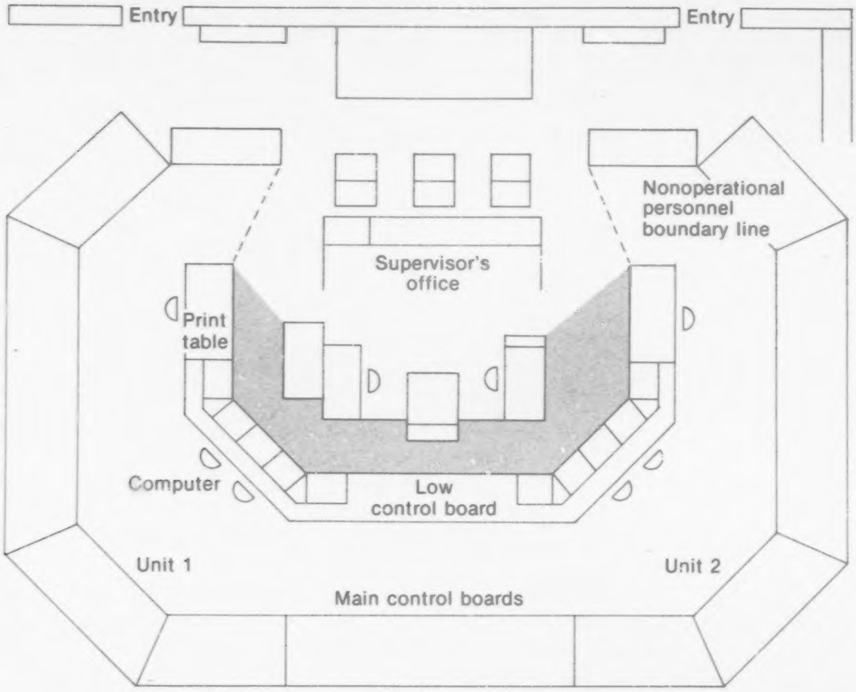
As with the panel's recommendations on 8- and 12-hour schedules, its recommendations on overtime are still under review by the NRC.

Overtime is necessary in outage situations, when every day off-line (not functioning) will result in lost revenues for the utility company. Employees often work 12-hour days in these situations. Overtime also increases when there are staff shortages, typically when someone fails to come to work. In such cases, workers may be required to work double shifts (if they are 8-hour shifts) or split the second shift with another worker. This type of shift activity may have negative effects on the worker, leading to performance decrements and interpersonal problems (1). Currently, there are few effective techniques for minimizing the physiological, psychological, and performance effects of overtime (see ch. 5).

THE JOB OF THE CONTROL ROOM OPERATOR

This section describes the work environment in the control room, the typical tasks for a control room operator, and the effects environmental and physiological factors can have on the performance of these tasks.

Figure 7-4—Example of a Control Room Configuration Used in a Nuclear Power Utility



SOURCE: Electric Power Research Institute, *Human Engineering Guide for Enhancing Nuclear Control Rooms*, Rep. No. NP-2411-project 501-4 (Palo Alto, CA: Electric Power Research Institute, 1982).

Control Room, Operator Tasks, Performance, and Fatigue

The nuclear powerplant control room consists of a panel board that operates each unit (i.e., the reactor containment building and associated systems). In facilities that have two reactors, there will be two control boards, which can be located either in the same or in separate control rooms. Figure 7-4 illustrates a typical control board configuration that is used in a nuclear utility.

The control board is made up of many switches, indicators, computer display systems, and alarm panels, each performing different functions. The two categories of personnel authorized to operate control units, reactor operators and senior reactor operators, are licensed by the NRC. Reactor operators are required to be alert and responsive at all times during the shifts. Their duties typically include monitoring the information displayed on the control board and overseeing the operations of all of the components of the control unit. They are required to execute a variety of monitoring tasks that require low-level, sustained vigilance but no physical activity. Thus, performing such tasks may result in sleepiness or fatigue, or both. Reactor operators' duties also include responding to a variety of alarms indicating that adjustments need to be made. If an emergency arises, they must be able to assess the situation and select appropriate procedures to mitigate it.

Senior reactor operators are responsible for overseeing the activities of the reactor operators in the control room. They are supervisors and have administrative, work control, and other company-related tasks. In addition, they must be ready at all times to back up the reactor operator.

Studies of tasks that require high levels of alertness and attentiveness have repeatedly found that human error increases after about half an hour of continuous vigilance (2). Since working on the same task and not moving around for a long period of time can cause fatigue, experts suggest that managers should attempt to vary operators' work tasks every 2 hours (2). Reactor operators are sometimes required to perform additional tasks outside of the control room, such as noting water level temperatures, checking the operations of radiation monitors, and performing general tasks for generator, turbine, and reactor upkeep. The more active nature of these duties can reduce fatigue. Experts have also suggested several other strategies to minimize sleepiness and fatigue (2). These include interventions that can be initiated by the operator:

- taking short walks during periods of low alertness,
- spending time each hour standing up and walking,
- avoiding getting too comfortable, and
- interacting with colleagues on the shift to help stay alert;

and interventions that would have to be implemented by management:

- scheduling tasks that involve physical activity on night shifts;
- allowing operators to take scheduled breaks away from the control panel;
- balancing the workload across shifts and days of the week to eliminate long periods of intense activity and stress;
- redesigning job responsibilities to maximize completeness, variety, and feedback in an effort to make jobs more interesting;
- not allowing individuals to work beyond their scheduled shift or to monitor the control board for over 2 hours without some relief (during the night shifts); and
- scheduling the shift workload so that difficult mental tasks are not required during periods of predictably low alertness.

Effects of Environmental and Physiological Factors on Vigilance

Several other factors can influence the vigilance of nuclear powerplant control room operators. These include lighting in the control room, ambient noise from the control panels and other machinery, ambient temperature, humidity, and ventilation, and the design of the work station. Each of these in some way or another can affect an operator's ability to carry out the job. Improper design of these variables can lead to fatigue, sleepiness, reduced attention span, and changes in mood that can result in errors in performance (2).

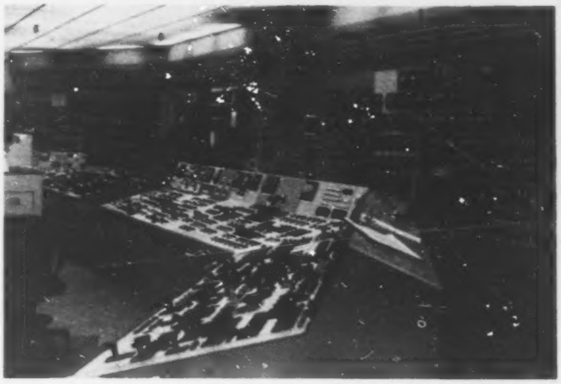


Photo credit: David Liskowsky

Control board at a nuclear powerplant.

While there is a substantial body of literature on the effects these factors can have on performance, there is little information available on the interaction of such effects with shift work schedules or the application of that information to the nuclear powerplant environment. Such research could greatly benefit the operators of nuclear powerplants.

MONITORING OPERATORS FOR PERFORMANCE CAPABILITIES

The primary responsibility for monitoring employees on the job rests with the management of the utility that operates the powerplant. The NRC's role is to ensure that the management control system at a plant is carrying out its responsibilities. One task of NRC resident inspectors is to monitor control room activities, including observation of control room personnel (24). In addition, the inspectors are required to spend approximately 10 percent of their time conducting unannounced control room inspections on the night shift. If an inspector observes that individuals are not performing their duties adequately, he or she notifies the appropriate supervisor.

Beyond the supervision provided by the utility management and the observational oversight of the NRC resident inspectors, there are no specific guidelines or regulations set forth by the NRC for monitoring control room operators for possible performance deficiencies related to sleepiness, fatigue, or disruption of biological rhythms. The NRC's Policy on Conduct of Nuclear Powerplant Operators (54 FR 1489-1498) and Regulatory Guide 1.114 (20) both state the Commission's expectation that operators be alert; moreover, since the Three Mile Island and Peach Bottom incidents, there has been a greater awareness among plant operators of the need to monitor control room operators. As a result, some plants have voluntarily carried out more comprehensive monitoring programs.

The purpose of such monitoring programs is to ensure that operators are capable of carrying out their duties on a routine basis. These programs use test batteries that are sensitive to decrements in performance caused by fatigue or disrupted biological rhythms. There is no one test battery capable of adequately measuring decrements in performance specifically for the control room operator. However, many general test batteries that are available assess deficiencies in performance, and these may be used for control room operators (see ch. 5).

It is not known how frequently voluntary monitoring programs are being carried out at nuclear powerplants. However, when monitoring occurs, it is usually a result of one of two circumstances: either a plant's management has noticed problems in control room operators' work practices and has requested a private testing organization to come to the facility and monitor the operators to help determine the nature of the problem, or a testing organization may approach the management of a nuclear powerplant and ask if it can run a series of tests on the workers to measure performance deficiencies and fatigue using its test battery. The latter affords the testing organization an opportunity to field test and market its test battery.

As previously mentioned, no NRC guidance exists regarding the use of formal testing procedures to monitor control room operators. In response to concerns about decreased performance due to substance abuse, however, the NRC has instituted regulations regarding a fitness-for-duty program for nuclear powerplant operators (54 FR 24468-24508). The fitness-for-duty program is intended to ensure that "all operators and plant personnel are reliable, trustworthy, and not under the influence of any substance (legal or illegal), or mentally or physically impaired from any cause, that would affect their ability to safely and competently perform their duties in any manner" (54 FR 24468-24508) (19, 22,23). Currently, the program is designed only to detect individuals using legal or illegal substances, not to determine decrements in performance caused by sleepiness, fatigue, or circadian desynchronization. **However, if deemed necessary or desirable, this program represents an existing mechanism that could be modified to include monitoring for decrements in performance due to the effects of shift work.**

SUMMARY AND CONCLUSIONS

NRC guidance related to overtime and shift length for nuclear powerplant control room operators is provided in Generic Letters 82-12 (15) and 82-16 (16); currently the Commission provides no guidance or policy regarding the design of work schedules. Recommendations have been made by a panel convened by a private laboratory under contract to the NRC, but no action has been taken on them to date and they remain under consideration by the NRC. Many nuclear powerplants use an 8-hour-per-day shift schedule; however, the trend is toward a 12-hour-per-day schedule.

Control room operators are responsible for the safe operation of the nuclear utility. Their duties involve engaging in continuous monitoring of all indicators on the control board and responding to numerous alarms. This generally does not require a great deal of physical movement. Furthermore, operators must be ready to respond to any emergency situation that may arise. This requires operators to be alert and attentive at all times while on duty.

Since working on the same tasks and remaining stationary for a long period of time can cause fatigue, experts suggest that managers who design work assignments attempt to vary operators' tasks every 2 hours. Experts have also recommended several strategies to reduce fatigue and sleepiness, since remaining awake late at night is often difficult. These may include allowing operators to take scheduled breaks away from the control panel and balancing the workload across shifts to eliminate continuous periods of stress.

Operators are sometimes required to work two consecutive 8-hour shifts, depending on the circumstances, or, especially in an outage situation, they may be required to work additional overtime. Such activities may have negative effects on the workers, leading to decrements in their performance.

In addition to shift work, several factors related to the environment and design of the control room can influence the vigilance of operators. Improper design of these factors can lead to fatigue, sleepiness, and reduced attention span, which could result in errors in performance. Research on the interaction of these factors with shift work effects in the nuclear powerplant control room environment could provide useful information to aid in plant operations.

Although the problems of fatigue and decreased performance capability in connection with shift work cannot be entirely eliminated, several steps can be taken to deal with them. One researcher (3) has suggested several possibilities, including:

> . . . make stricter regulations regarding shift work scheduling; designing schedules to meet the health and safety needs of the plant and its workers; improve the design and lighting of the control room; improving incident reporting systems and incident analysis to ensure that proper remedies are applied regarding the problems associated with 24-hour operations; and continued research and further studies to gain more knowledge and understanding of the impacts from circadian disruption due to shift work on the safety and health of nuclear powerplant control room operators.

One of the duties of the NRC's resident inspectors is to oversee the supervision of operators by the utility. Currently, there is no NRC guidance or policy regarding the monitoring of control room operators for specific performance deficiencies related to fatigue or disruptions of biological rhythms. In some cases, powerplants voluntarily institute a monitoring program using standardized test batteries administered by outside organizations, although it is unclear how frequently this occurs. The NRC's fitness-for-duty program is designed to detect workers who are using legal or illegal substances, not to determine decrements in performance due to decreased attention span and alertness that could be associated with work schedules. The NRC could require that the fitness-for-duty program be restructured to include measures of performance deficiencies resulting from shift work.

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Chapter 8

Case Study: Registered Nurses and Resident Physicians

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Chapter 8

Case Study: Registered Nurses and Resident Physicians

Health care is a 24-hour-a-day business. People get sick and need care around the clock, and hospitals must be staffed with health care professionals ready to meet those needs. This means that some health care employees, such as nurses and residents,[1] must work at night, on weekends, and on holidays. Extended duty hours and circadian rhythm disruption play a major role in the training of residents. Historically, that training has been marked by long, intensive hours over several years. Some residents have worked more than 130 hours per week in shifts of 12 to 60 hours, with every other night on call (58). The resulting sleep deprivation is a major source of stress in residency (23). Likewise, many nurses must work nondaytime shifts and endure the resulting circadian rhythm disruption for the duration of their professional lives.

Although the issues discussed in this case study affect some portion of virtually every group working in hospitals (e.g., laboratory and x-ray technicians, pharmacists, transport teams, chaplains, social workers, runners, admitting clerks, housekeepers), the focus here will be limited to nurses and residents. This case study examines the effects of shift work on the health and well-being of nurses and the quality of care they deliver and how the structure of resident training programs may result in sleep deprivation that can affect the health and well-being of residents and their patients.

SHIFT WORK IN NURSING

> Jane Doe . . . worked as a registered nurse (R.N.) at a hospital on the West Coast. She had been working all night and was in the 12th hour of a 12-hour shift. She was under time pressure to complete her work. She was disconnecting a patient's I.V. and had to dispose of a used I.V. needle. In the process, she was accidentally stuck by the needle, which turned out to contain HIV-infected blood. Jane Doe seroconverted and is now HIV-positive. The fact that she was tired at the end of a 12-hour shift, that the hospital was understaffed, and that the hospital did not have proper containers accessible to dispose of sharp needles all combined to create a hazardous working condition, with tragic results (88).
>
> A nurse at a Northeastern hospital was on restricted duty due to a heart condition but eventually was required to work 18 hours straight. She was on medication and increased the dosage to help cover the demands of her work situation. She became ill, and her case, along with 14 others, was submitted to labor arbitration (105). The case was settled just prior to the arbitration hearing (98).
>
> A malpractice case was filed against a nurse in the Northeast because a patient died during the nurse's second continuous 8-hour shift (105).

Registered Nurses: An Overview

Anecdotes such as these are easy to find, but the contribution work hours may play in them is difficult to document. Several explanations for this seem plausible. First, statistics on the relationship between hours of work and adverse events for nurses are not tallied by the U.S. Department of Labor, and there is no statutory requirement that unions or employers collect such data. As illustrated by the case of Jane Doe, extended duty hours may be only one of several factors contributing to an incident, and a nurse may therefore not interpret an incident as related to shift work. Even if nurses do believe that shift work is causing problems, they may find it difficult to prevail when they file grievances over shift work issues unless these issues are covered in their collective bargaining agreements. Nonunion nurses often work at facilities without formal grievance procedures and thus may have less opportunity to pursue shift work concerns through a structured complaint process (89).

A number of unions representing nurses, including the American Nurses Association, Service Employees International Union, American Federation of State, County and Municipal Employees, and the Federation of Nurses and Health Professionals (a division of the American Federation of Teachers), bargain over shift assignments, length of time between shifts, shift of choice, split shifts, and shift rotations for nurses. In the words of one union employee, however:

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[1] For the purposes of this chapter, a resident is any postgraduate medical trainee, including interns, in both medical and surgical specialties. Residents are also referred to as house officers or house staff.

> . . . our success at limiting shift work through the collective bargaining process has been modest at best. We attribute this in part to the lack of any legal or regulatory framework on shift work and extended hours. It is very difficult to persuade employers to adopt measures that exceed existing legal requirements. In addition, in many of these industries, shift work and night work are unavoidable. In these cases, we attempt to give the employees more of a choice and more control over their hours of work (88).

Some nurses must work extended hours as a condition of their employment, while others welcome the opportunity to mass their hours. Both situations may present challenges to the well-being of nurses, their families, and their patients. This section reviews research on shift work in nursing and the consequences of shift work for family and social life, health, and work performance of nurses.

R.N.s are the largest health care profession.[2] According to a recent survey, there were 2,033,032 R.N.s licensed to practice in the United States in 1988, of whom 1,627,035 (80 percent) were employed in nursing positions (67). **Nursing is predominantly a woman's profession; in 1988, only 3 percent of registered nurses were men.** In addition, 71 percent of R.N.s were married, and 54 percent had at least one child living at home. One-half of all R.N.s in 1988 were under age 40, and 63 percent were under age 45. Thus the majority of nurses have families or are in their childbearing years, sociodemographic factors that bear on shift work.

Of those employed in nursing in 1988, 68 percent were working full-time and 32 percent were working part-time. Hospitals traditionally have been the principal employer of R.N.s. In 1988, 68 percent of employed registered nurses worked in hospitals, and no other single type of employment setting accounted for more than 8 percent of employed nurses. Nursing homes and other long-term care facilities employed only 7 percent of R.N.s in 1988. Ninety percent of R.N.s employed in hospitals in 1988 worked in non-Federal, short-term care hospitals, 6 percent worked in Federal Government hospitals, and 4 percent worked in non-Federal, long-term care hospitals. Among R.N.s working in hospitals in March 1988, 2.7 percent (or 30,358 nurses) were working through a temporary employment service (67).

Prevalence

No national survey of R.N.s provides estimates of the prevalence of shift work or the number of years the typical R.N. spends in shift work during her or his career. **However, since the organizations that employ the vast majority of nurses—hospitals, nursing homes, and other extended care facilities—require 24-hour operations, it is likely that a sizable proportion of R.N.s are engaged in shift work.** Moreover, many nurses also work overtime, since they draw time-and-a-half pay for overtime (62). Data from one survey show that among 764 responding community hospitals, an average of 71 percent of R.N.s were reported to work some nondaytime hours, and an average of 33 percent of R.N.s worked some combination of day, evening, and night shifts, including rotating all three shifts; furthermore, only 7 percent of R.N.s had every weekend off (1).

Another survey reported that 46 percent of R.N.s employed in nursing homes in 1985 worked nonstandard hours, and 9 percent worked rotating shifts (107). The smaller proportion of R.N.s on rotating shifts in nursing homes compared with hospitals could be attributed to the fact that nursing home R.N.s are more likely to be in supervisory positions than in staff positions.

Estimates for the total U.S. labor force suggest that shift work is more prevalent among nurses than women workers in general (see ch. 4). Data collected in 1985 on wage and salary workers age 16 and over revealed that 13 percent of full-time women workers and 43 percent of part-time women workers were involved in some type of shift work. Among full-time workers in health assessment and treatment occupations (the category that includes R.N.s), 31.3 percent were in some type of shift work. Rotating shifts were the most frequent kind of shift work in these occupations. (Ch. 4 gives a more thorough discussion of the extent of shift work in the labor force.)

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[2] This report pertains to registered nurses. Nursing personnel in the U.S. health care industry include registered nurses, licensed practical-vocational nurses, and unlicensed ancillary personnel, including nursing aides. It is estimated that these three occupations included over 3 million persons employed in health care in 1984 (108).

Photo credit: Joint Commission on the Accreditation of Healthcare Organizations

Nurses tend to patients within view of the nursing station.

Patterns

Traditionally, hospitals and nursing homes have operated on three 8-hour shifts (day, evening, and night shifts), with nurses typically working five 8-hour shifts per week on either a fixed or rotating basis, including weekend work.[3] Shifts typically overlap for one-half hour, in order that nurses leaving the unit can communicate with those arriving regarding patient status or anticipated admissions. The pattern of activity in hospitals varies by time of day, so the tasks and workloads of nurses can vary by shift. Night shifts are generally considered to be slower and to require a smaller complement of nurses, since most patients are asleep and fewer procedures take place at night. A possible exception might be the emergency room, where activity can be frenetic during the night shift. On the other hand, night nurses are expected to be able to manage emergencies when other services are not readily available.

Shift patterns (e.g., timing and length of shifts, patterns of rotation), the method of shift assignment (the degree to which nurses can control their assignments by bidding on preferred shifts or trading shifts), and compensation for shift work (e.g., higher hourly wages for undesirable shifts) are determined by the employing organization and vary widely. In some decentralized organizations, these policies are determined at the unit level. Some aspects of shift work, such as requirements regarding rotation, mandatory overtime, or pay differentials, become issues in collective bargaining by nurses, although only 20 percent of hospitals report having organized collective bargaining for R.N.s (predominantly through State nurses' associations) (1).

Typically, nursing coordinators or nursing managers have authority over shift assignments for staff nurses and resolve scheduling conflicts. Assignments to undesirable shifts (e.g., night or weekend work or rotating shifts as opposed to fixed shifts) are often an inverse function of seniority. Some nursing administrators reward seniority with more desirable shifts as a retention strategy (61).

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[3] In nursing, the day shift typically refers to the 8-hour shift occurring during daytime hours (e.g., 7 a.m. to 3:30 p.m.), as contrasted with evening (e.g., 3 p.m. to 11:30 p.m.) and night shifts (e.g., 11 p.m. to 7:30 a.m.). In this chapter, nurses who work fixed day shifts are *not* regarded as shift workers.

Six distinct hospital scheduling alternatives appear to exist, although some are used in very few hospitals. The models are:

- the traditional five 8-hour shifts per week, including rotation within a 1-week cycle;
- the "Baylor Plan," consisting of two or three 12-hour shifts for separate weekend staff, with the regular staff working traditional 8-hour shifts;
- "4 to 40," consisting of four 10-hour shifts per week;
- "7-on, 7-off," consisting of seven 10-hour shifts on alternative weeks;
- "12-hour shifts," consisting of three 12-hour shifts one week, four 12-hour shifts the next; and
- "customized schedules," involving choice of various shift lengths (47).

Traditional 8-hour shifts continue to predominate in nursing. Community hospitals report that nearly 79 percent of R.N.s, on average, work 8-hour shifts, 17 percent work 12-hour shifts, and 4 percent work other types of shifts, including partial shifts of 4 to 6 hours (1). Although a number of experiments with hospital shift lengths and patterns have been reported, these appear to affect a relatively small proportion of R.N.s. For example, one hospital in North Carolina has reported a 12-hour shift system in which nurses work seven 12-hour days in succession, followed by 7 days off (40). Urban hospitals appear to be more innovative with regard to shift issues because they face greater competition for nursing staff (61). At Johns Hopkins Hospital, a professional practice model, in which the nurses agree to provide 24-hour coverage of their unit in exchange for self-management and annual salaries, has been in place on some nursing units since 1981. The model permits nurses to design their own shift systems and to make and monitor their own shift assignments (27).

Differentials in pay for shift work are used widely by U.S. hospitals. In a 1988 survey, over 97 percent of hospitals reported paying more to full-time and part-time R.N.s for evening and night shifts (1). However, only 41 percent of hospitals reported paying more for weekend shifts (1). In 1987, the average hourly differential paid for the evening shift by U.S. hospitals was $0.79, for the night shift $1.02 (5). Nonfinancial compensation for shift work (e.g., extra days off or child care) is rare. The effectiveness of pay differentials in attracting nurses to undesirable shifts is unknown. Box 8-A discusses shift work schedules for nurses in Great Britain.

Box 8-A—Impact of Shift Work on Nursing in Great Britain

A recent study for the British Department of Health entailed a survey of the shift schedules in effect in large (400+ beds) general hospitals in England and Wales. Over 50 percent of all such hospitals supplied details of their shift schedules. Only a small minority of hospitals (less than 20 percent) had a regular shift schedule. The majority of hospitals (65 percent) claimed to have a flexible system in which the individual nurses' requests were taken into account when drawing up the duty rosters. The remainder had an irregular system in which no account was taken of nurses' requests.

Despite these differences, timing and duration of shifts were remarkably consistent among hospitals. Approximately 80 percent of the early morning shifts started between 7:30 a.m. and 8 a.m. and lasted for 8 to 8.5 hours. The starting time, but not the duration, of the late afternoon shift was slightly more variable. Ninety percent started between 12:30 p.m. and 2 p.m. Similarly, most night shifts started between 8:30 p.m. and 9:30 p.m. and lasted between 10 and 12 hours. Perhaps more important, while new schedules involved more than two or three successive early or late shifts, spans of seven or eight successive night shifts were not uncommon. These data contrast with U.S. patterns, presumably reflecting national differences.

SOURCES: Office of Technology Assessment, 1991; based on S. Folkard, Department of Psychology, University of Sheffield, Sheffield, United Kingdom, personal communication, January 1991.

Evidence of Dissatisfaction With Shift Work

A number of polls and research studies conducted during the last decade provided evidence that shift work, or the nurse's perceived lack of control over scheduling, was associated with job dissatisfaction and turnover. However, few prospective studies of job satisfaction have distinguished between the effects of shift work and other job, organizational, or personal attributes. Results of a 1981 Texas survey of 3,500 nurses suggested that work overload and shift work issues were intermingled and that, in general, nurses desired greater control over work assignments and scheduling (113). (The job condition eliciting the most dissatisfaction, however, was salaries.)

In one 1987 poll, 1,643 nurses were asked what caused them the greatest dissatisfaction with their jobs:

- 76 percent of nurses responding said increased work hours;
- 51 percent of nurses responding said increased shift rotation; and
- 43 percent of nurses responding said increased weekend work due to the current nursing shortage.

In addition, 65 percent of nurses responding said that a minimum of every other weekend off was most important in evaluating their present jobs, and 53 percent reported that a permanent shift assignment was most important. (Salary and benefits were ranked equal in importance with a permanent shift assignment) (30).

A 1-year prospective study of nursing job satisfaction and turnover asked R.N.s in two large university-affiliated hospitals to report their satisfaction with scheduling of work hours. Overall, nurses were dissatisfied with their scheduling (114). In one hospital, working rotating shifts, as opposed to fixed shifts, was found to lower nurses' perceptions of their control over the work environment. Lower perceived control, in turn, was the strongest predictor of job dissatisfaction. In the second hospital, shift work had no significant impact on perceived control (115).

A study of job satisfaction of R.N.s in five short-term acute care hospitals measured satisfaction at two points, 8 months apart. Assignment to the day shift was associated with higher job satisfaction (12). A study of 146 nursing units in 17 hospitals examined unit-level determinants of turnover rates. Greater shift rotation among R.N.s in a unit was seen as an indicator of less staff cohesiveness, which was predicted to produce higher rates of turnover. In fact, extent of shift rotation was found to be a marginally significant predictor of turnover rates (2).

Only one randomized trial of different shift patterns in nursing has been reported. In a 788-bed tertiary-care hospital (i.e., a hospital that provides highly intensive, sophisticated care for medical conditions that are difficult to manage in a community hospital), 12 randomly selected medical-surgical units staffed by both R.N.s and licensed practical nurses (L.P.N.s) were assigned at random to one of four schedules:

- fixed shifts;
- computer-assisted scheduling in which nurses' shift preferences were considered;
- select-a-plan, in which unit nurses designed their own scheduling system, typically combining 8- and 12-hour shifts; and
- a control group.

Descriptions of job attitudes were obtained from 98 percent of nurses before and after the shift assignments, but the length of the followup period is unspecified. The results did not indicate substantial variations by schedule in R.N.s' job attitudes or turnover at followup (20).

A number of commissions and task forces in recent years have recommended that health service organizations address the issue of shift work. A 1981 study of nursing and nursing education noted flexible scheduling as a strategy to increase nursing labor supply to hospitals and nursing homes (48). A 1983 report recommended that flexible scheduling be developed as a component of models for organizational change in nursing (68). A study of magnet hospitals found that flexible scheduling and elimination of rotating shifts were among the four most important factors promoting recruitment and retention of nursing staff (3).

A consensus appears to have developed regarding the need to provide shift work alternatives for nurses and to increase nurses' involvement in scheduling decisions. A 1988 report cited work scheduling as a major source of stress among hospital R.N.s (108). Most recently, the authors of a study of 421 hospitals and over 15,000 nurses in six urban areas recommended that hospitals offer varied and flexible schedules as a means of responding to the work preferences of nurses and resolving the current nursing shortage (91).

Consequences of Shift Work in Nursing

While there is a body of research that addresses the consequences of shift work on the health, well-being, and performance of workers in a variety of industries, these industries employ mostly men; relatively little research has been conducted specifically on women shift workers (24). As a result, it is difficult to generalize about nurses from existing studies. (The consequences of

Photo credit: Harvard Community Health Plan

Patient getting his blood pressure checked by a nurse.

shift work are discussed more fully in ch. 5.) In nursing, type of shift is often confounded by age, because younger, less experienced nurses tend to be assigned to rotating shifts. This discussion of consequences focuses on studies in which nurses have been subjects, but it will allude occasionally to studies of other women shift workers or to the absence of information about women shift workers.

Work Performance

Studies of the work performance of shift workers have generally focused on lost productive time as a consequence of health problems (e.g., absenteeism due to illness or use of health services) and on errors and injuries as a consequence of fatigue or disrupted circadian rhythms. A few studies of nurses have reported results for sick days, use of health services, self- or supervisor-reported performance levels, and various indicators of quality of patient care.

Sick Days and Use of Health Services—A 1977 study of the health consequences of shift work conducted by the Stanford Research Institute for the National Institute for Occupational Safety and Health (NIOSH) used employee records to study sick days and clinic visits by nurses on four shifts. (The number of sick days alone is not a reliable indicator of health problems, since sick days are limited by personnel policies.) **Nurses on a rotating schedule tended to take more sick days than nurses on fixed shifts, and rotating nurses tended to have more serious reasons for taking sick days (e.g., acute respiratory infection, upper gastrointestinal tract distress).** With regard to clinic visits, rotating nurses attended workplace clinics during work hours more frequently than fixed shift nurses and for a wider array of complaints (103), indicating that rotating nurses lose more time from work (due to both sick days and clinic visits) and could be less productive on the job.

Job Performance Ratings—A few studies of the effects of shift work on the job performance of individual nurses have used self-reports of performance or the reports of supervisors. The NIOSH study found that nurses on fixed afternoon-evening and rotating shifts reported lower levels of satisfaction with their work performance than did fixed night and day shift nurses (103). Another study found that nurses on rotating shifts received lower job performance ratings by their supervisors, compared to nurses on fixed shifts (49).

In a recent study of job performance and job-related stress among 482 R.N.s in five hospitals in the Southeastern United States, self-reported job performance was examined in relation to type of shift worked. On overall job performance, nurses on rotating shifts reported the lowest performance level, followed by fixed afternoon nurses, fixed night nurses, and fixed day nurses. The investigators found that only one of a number of dimensions studied was significantly associated with shift: for performance with regard to professional development, rotating and fixed afternoon nurses scored themselves lower than fixed-day and fixed night nurses. There were no significant differences by shift for leadership, teaching-collaboration, planning-evaluation, or interpersonal relations-communications. Rotating nurses also reported the highest levels of job-related stress. These relationships held when anticipated turnover, position level, and length of time on the present shift schedule were controlled (21).

Quality of Patient Care—**Very little research has been conducted on the relationship between shift work and quality of patient care by nurses.** The few studies that have addressed the effects of shift work on quality have been small-scale evaluations of shift work demonstration projects.

In nursing studies in general, quality of care is typically measured in terms of the nursing care process rather than patient outcomes. Process measures of quality usually take place at the unit level and involve chart audits, in which raters examine nursing care plans to determine whether specific procedures have been recorded. An alternative method is direct observation of nursing procedures, in which a rater assesses performance along a number of dimensions. Other indicators of quality include incident reports (medication errors, accidents, or injuries) and patient satisfaction. One should remember, however, that quality of care as defined by provider and quality of care as defined by patient may not be the same (15).

Research to date implies two mechanisms by which shift patterns might affect quality of nursing care. First, shift work patterns that are more compatible with circadian rhythms would be expected to result in less fatigue and increased alertness on the job. Second, shift work patterns that are more satisfying to nurses would be expected to result in greater nurse retention, unit cohesiveness, and continuity of care across shifts.

A 4-month trial of the 4 to 40 workweek (four 10-hour days per week) in a pediatrics unit employing both R.N.s and L.P.N.s was conducted in Seattle, Washington. The new scheduling system, compared to the traditional 8-hour, 5-day shift system, was expected to improve quality of care, defined in terms of intershift continuity of care. Process measures of nursing care quality revealed little change from the traditional system. Staff reports of quality, however, did show improvement (50).

In another program, a 12-hour shift system was introduced on an intensive care unit and evaluated over a 6-month period. The impact of the 12-hour shift, compared to the traditional 8-hour shift pattern, was measured with regard to nurses' job satisfaction, interpersonal relations in the work environment, nurses' health status, nurses' fatigue and alertness, and quality of patient care. No significant differences were found between types of shift for alertness (reaction times) or fatigue, although in the 12-hour shift system reaction time was faster for day shift than for night shift nurses. Using retrospective analysis, the investigators found no significant difference between the quality of nursing care at the time studied and that during a corresponding period of the previous year. Data from incident reports showed no change in the rate of incidents with the switch to 12-hour shifts (29).

In a pilot study of 12-hour shifts in a surgical intensive care unit, quality of patient care prior to implementation of 12-hour shifts was compared to quality of care 1 year later. Some increase in subjective feelings of fatigue and decreased accuracy on performance tests was reported, but evidence from chart audits revealed no significant changes, and nurses perceived that their performance improved (63).

One small study compared 10 R.N.s working 8-hour shifts with 10 R.N.s working 12-hour shifts in the intensive care units of two Midwestern hospitals. The Quality Patient Care Scale (QUALPACS) was administered by an observer to provide concurrent ratings of patient care provided by each nurse. Only one of five behavior categories rated by the QUALPACS demonstrated a statistically significant difference between 8- and 12-hour shift workers, although nurses on 12-hour shifts scored lower than nurses on 8-hour shifts on all of the dimensions. Since most of the 12-hour nurses volunteered comments about the fatigue they experienced, the investigators interpreted these results as indicating potential problems with quality of care on 12-hour shifts (69).

It is not known how extended workdays and compressed workweeks affect patients' satisfaction with nursing care. Conceivably, patients could react differently to various shift schedules, depending on the availability of their primary care nurse. One study reports anecdotal evidence of patient satisfaction with a 12-hour shift system in which nurses worked 7 consecutive 12-hour days followed by 7 days off (40). However, patients who do not see their primary nurse for days at a time may experience this as discontinuity in their care.

Health

As discussed in chapter 5, shift work can affect health. Disruption of circadian rhythms because of shift work could have differing effects on men and women due to hormonal differences between the sexes. Differences between men's and women's circadian rhythms and adjustment of these rhythms to shift work have been studied, but no definitive conclusions have been drawn (8). Congressional interest in research on women's health, as exemplified by the Women's Health Equity Act of 1991, supports the theory that the results of research on male subjects cannot be assumed to apply to women.

Table 8-1 lists recent studies of health outcomes of shift work in nursing. The key findings are discussed below. **Research has demonstrated that nurses working night and rotating shifts suffer more sleep disturbances than other nurses and may be at higher risk for various other health problems** (89).

Sleep Disturbances—Deficits in the quantity or quality of sleep are associated with physical or emotional disorders and with problems in alertness and performance that can produce injuries on the job. All but one of the studies summarized in table 8-1 measured quantity or quality of sleep as a function of nurses' shift work. Outcomes studied included amount of sleep, sleep stages and rapid eye movement (REM) sleep, interruptions of sleep, and subjective fatigue. A frequent focus has been the adaptation of sleep patterns to different amounts of night work. In general, nurses working rotating shifts and night shifts involving only a few nights on duty had more sleep disturbances than other nurses, although few studies compared nurses on a variety of shifts or controlled for such variables as age, shift work history, and family circumstances. None of the studies examined the effects of chronic sleep disruption on nurses' health or work performance.

Several of the studies made a distinction between part-time and full-time night nurses (e.g., those working only 2 nights a week or 2 nights in succession compared to those working more than 2 nights a week or in succession) in an effort to study short-term compared to long-term sleep adjustment to shift work. These studies found that full-time night nurses were better adjusted than part-time night nurses in terms of quantity and quality of sleep (34,64,65). Such adjustment was attributed in part to greater commitment to night work among full-time night nurses, as well as to greater compatibility of family situations with night work and day sleep among these nurses (e.g., no children at home).

The dual issues of a selection effect (i.e., nurses selecting shift work based on compatibility with lifestyle) and family roles as mediating variables in adjustment to night work were noted in most of the studies. **For women night shift workers more than for men, family responsibilities (e.g., child care, carpooling, housework) during nonworking hours take precedence over the need to compensate for lost sleep** (39). Duration of sleep was found to be greater among unmarried subjects than among married subjects with children (39). **Nurses' lifestyles, not just their shift patterns, determine sleep patterns** (39). Another study found that fatigue in nurses working nights (in a sample of nurses who worked various shifts at irregular intervals) appeared to be due to social factors (number of children, age, and being married or living with a partner) (45). Greater number of children also decreased the amount of sleep achieved by nurses after work on the night shift.

The NIOSH study mentioned earlier (103) found that **nurses on fixed night shifts and on rotating shifts generally reported more problems with sleep, as compared with nurses on fixed day or fixed afternoon or evening shifts.** These included subjective reports on the overall adequacy of sleep, trouble falling asleep, awakening during sleep and falling asleep after awakening, waking up feeling tired, and feeling tired during work. **Although nurses on all four types of shifts reported desiring the same amount of sleep, nurses on fixed night shifts reported getting the least sleep. Further, rotating shift nurses, compared with those on fixed shifts, showed significantly higher incidence of fatigue and inadequate sleep patterns when the effects of age and marital status were controlled** (103).

Digestive Disorders—The NIOSH study reported data on nutritional intake, appetite, and digestive problems among nurses by type of shift. Nurses on fixed afternoon or evening shifts reported better appetites than nurses on other shifts. Night shift nurses reported needing fewer meals in a 24-hour period than other nurses, and day shift nurses reported needing the most. Rotating shift nurses reported more snacking. Day nurses reported the most meals eaten with family or friends.

Rotating and day nurses reported significantly more bloating or feeling full; rotating and afternoon nurses reported more gastritis; and rotating nurses had higher incidence of trouble digesting food. **Rotating shift nurses showed a significantly higher incidence of digestive trouble than other nurses, when age and marital status were controlled** (103).

In another study, nurses working three or more consecutive nights exhibited greater adjustment in their meal times during a period of 12 consecutive days than nurses working single nights or only 2 nights in succession. Nurses working more nights

Table 8-1—Studies of Health Consequences of Shift Work in Nursing

Study	Sample	Shifts compared	Major findings
Bryden and Holdstock, 1973	12 nursing students in 1 hospital in South Africa (all female)	Day shift, night shift in same nurses	Daytime sleep was shorter than night sleep and had more interruptions. REM[a] sleep occurred sooner in day sleep than in night sleep.
Felton, 1976	39 nurses in Hawaii (all female)	Night shift, postnight duty in same nurses	Peak body temperature; excretion of sodium, potassium, and creatinine in the urine; and osmolality (concentrations of these substances in the urine) occurred later in the day in nurses on night duty. After returning to day shift, nurses' urinary sodium, creatinine, and osmolality cycles returned to baseline pattern, but temperature and potassium did not after 10 days of followup. Fewer hours of sleep and poorer quality of sleep reported while on night duty.
Folkhard et al., 1978	30 nurses in 1 hospital in England (all female)	Early and late day shifts, permanent night shift (full-time, 4 nights/week; part-time, 2 nights/week)	Circadian rhythms (oral temperature, subjective alertness and well-being) of full-time night nurses showed greater adjustment than those of part-time nurses, both on first night shift and in adjustment from first to second nights. Part-timers reported less sleep and less "calmness" on waking.
Gadbois, 1981	898 nurses and nursing auxiliaries in 61 hospitals in France (all female)	Fixed night work only (varied number of nights on duty)	Self-reported sleep duration was shorter, and sleep interruptions more frequent, for married women with children than for unmarried women. Mothers with young children went to bed later in the day.
Harma et al., 1988	128 nurses and nursing aides in 1 hospital in Finland (all female)	Irregular rotating shifts only (combinations of day, evening, night shifts in 3-week cycles)	Neuroticism and morningness were found to increase shift-cycle fatigue, and greater maximal oxygen consumption decreased it. Morningness, older age, and having children decreased sleep duration after night shift. Shift work experience and morningness decreased sleep quality after night work, and oxygen consumption increased it. Gastrointestinal symptoms were increased by neuroticism, marriage, and older age. Neurovegetative symptoms were increased by marriage and neuroticism. Musculoskeletal symptoms were increased by marriage, neuroticism, and physical activity and were decreased by oxygen consumption and muscle strength.
Hildebrandt and Stratmann, 1979	6 nurses in Germany	7- to 18-day period of night work compared with 10-day recovery period in same nurses	Three "evening type" nurses reacted to night work with flattening of circadian amplitude (temperature and heart rate) and greater tolerance. Three "morning type" nurses developed increased amplitude, higher amounts of subjective complaints (e.g., headache, nervousness, irritation), greater compensation for lost sleep, and lower subjective vigilance.
Infante-Rivard et al., 1989	418 nurses and nursing aides in 1 hospital in Canada (all female)	Fixed day, fixed evening (within both groups, comparisons between those with and without prior night work)	Prevalence of 9 sleep disorder symptoms ranged from 6 percent to 53 percent. Evening workers were at higher risk of not being alert and receptive at rising and at lower risk of early morning awakening. Prior night work was associated with day tiredness and quantity of sleep.

Table 8-1—Studies of Health Consequences of Shift Work in Nursing—Continued

Study	Sample	Shifts compared	Major findings
Kuchinski, 1989	146 R.N.s[b] in 1 hospital in Cincinnati (all female)	Fixed shifts, rotating shifts	No differences by shift were found in menstrual interval, duration of flow, amount of flow, dysmenorrhea, intermenstrual bleeding, or secondary amenorrhea.
LeClerc et al., 1988	824 nurses in 10 hospitals in France	Permanent day, permanent night, rotating without night, rotating with <5 nights/month, rotating with 5+ nights/month	For 38 health variables, including symptoms and health services utilization, type of shift had poor explanatory power.
Matsumoto, 1978	5 nurses in 1 hospital in Japan	Day shift, night shift in same nurses	Time in bed and total sleeping time were lower in daytime than nighttime sleep. Number of awakenings was greater in day sleep. Daytime sleep differed qualitatively from night sleep in appearance of REM and non-REM sleep.
Minors and Waterhouse, 1983	26 nurses	Single nights, paired nights, nights in blocks of 3+	Nurses working single nights maintained a conventional diurnal routine. Nurses working a number of consecutive nights showed changes in routine, including afternoon napping and different meal times.
Minors and Waterhouse, 1985	14 volunteer nurses in 1 hospital in England (11 female)	Short-term night shift (1 to 3 successive nights), long-term night shift (3 successive nights)	Nurses working 3 successive nights were better adjusted to nocturnal activity and diurnal sleep, as reflected in amount of sleep, afternoon naps, and fewer subjective complaints.
Tasto et al., 1978; Smith et al., 1979	1,219 full-time nonsupervisory R.N.s and L.P.N.s[c] in 12 U.S. hospitals (1,195 female)	Fixed day, fixed afternoon/evening, fixed night, rotating	Nurses who rotate shifts took more sick days than nurses on fixed shifts, suffered more injuries, and reported more digestive trouble, leg and foot cramps, colds, nervousness and shaky feelings, fatigue and exhaustion, use of stimulants, use of beer and liquor, tension or anxiety, depression or dejection, confusion or bewilderment, neuroticism, sleep disturbances, and problems adjusting work schedules and family life.
Verhagen et al., 1987	167 nurses in 6 hospitals in Belgium (all female)	Permanent night (full-time and part-time), 2-shift rotation with some nights	Rotating nurses reported more health complaints. Permanent nurses slept less than rotating nurses.
Webb, 1983	19 nurses age 50 to 60 in 3 hospitals in Florida compared with forty 50- to 60-year-old female university employees with no history of shift work	Current night shift with 10 years of rotating shift experience; nurses not on current shift work but extensive night or rotating shift experience; nurses not on current night shift and limited prior shift experience	Little evidence of enduring effect of night shift experience on sleep patterns. Some evidence of moderately changed REM sleep.

[a] REM, rapid eye movement.
[b] R.N., registered nurse.
[c] L.P.N., licensed practical nurse.

SOURCE: Office of Technology Assessment, 1991.

tended to have their evening meal around midnight, indicating a commitment and long-term adaptation to night shift work (64).

Being married increased the reported incidence of gastrointestinal symptoms (poor appetite, gaseous distention, heartburn, constipation, and diarrhea), nervous and psychological symptoms (nervousness and tautness, headache, nightmares, giddiness and nausea, palpitation or irregular heartbeat, hand sweating, pricking or numbness of body parts, decrease in libido), and musculoskeletal symptoms (back symptoms, neck, shoulder or hip symptoms, knee or ankle symptoms) (45).

Psychological and Nervous Symptoms—Psychological variables may be interpreted as outcomes of shift work or as outcomes of mediating variables. The NIOSH study used the Profile of Mood States (POMS) to measure psychological state and the Eysenck Personality Inventory (EPI) to assess personality traits. Psychological state changes over time, while personality trait is more or less constant (25,54). On the POMS subscales:

- nurses on a rotating shift reported significantly higher tension and anxiety than afternoon-evening and night workers;
- rotating nurses reported significantly more depression and dejection than day or night workers;
- rotating nurses reported significantly less vigor and more fatigue than nurses on all other shifts; and
- rotating nurses reported significantly more confusion and bewilderment than nurses on all other shifts.

On the EPI, nurses on a rotating shift were significantly more anxious and irritable than nurses on other shifts. Interestingly, day shift nurses scored lower on sociability than afternoon-evening and night nurses (103).

Anxiety, irritability, and nervousness increase shift-cycle fatigue in nurses and contribute to a higher reported incidence of gastrointestinal, nervous, psychological, and musculoskeletal symptoms, regardless of shift (45). A measure of morningness (preferring daytime activity) as opposed to eveningness (preferring nighttime activity) was also predictive:

- morningness decreased reported fatigue in morning shift nurses and increased it in evening shift nurses; and
- morningness also decreased the duration and quality of sleep after night shift work (45) (see ch. 5).

The relationship between specific psychological symptoms and degree of social interaction, which may be reduced by shift work, is not known.

Menstrual Dysfunction—Few studies have examined the relationship between shift work and reproductive health in nurses, although environmental and occupational conditions can contribute to menstrual dysfunction (51). The NIOSH study included some indicators of menstrual dysfunction and found that nurses on fixed day shifts reported more irregular menstrual periods than other nurses and that nurses on all types of fixed shifts reported more menstrual cramps than did rotating nurses. Night and rotating nurses, however, reported spending more time lying down due to menstrual cramps, and rotating nurses reported more tension, nervousness, weakness, and sickness at menstruation, as well as longer periods, than did nurses on other types of shifts (103).

In a recent study of the menstrual characteristics of 146 R.N.s age 20 to 40 in a university hospital, 43 percent of the nurses studied worked fixed shifts and 57 percent worked rotating shifts. No significant differences between these two groups of nurses were found for self-reported length of the menstrual period, duration of flow, amount of flow, dysmenorrhea, intermenstrual bleeding, or secondary amenorrhea (55).

Substance Use and Abuse—Only the NIOSH study has reported differences in nurses' substance use by type of shift:

- rotating nurses, compared with nurses on fixed shifts, were more likely to use stimulants;
- rotating and afternoon shift nurses drank more beer;
- rotating nurses drank more alcohol of all kinds;
- rotating and day shift nurses were more likely to drink on workdays; and
- night nurses were more likely to drink before going to work.

The information obtained on quantity of alcohol consumed was limited, and no conclusions can be drawn regarding alcohol dependency. Similarly, it is not possible to determine from the reported data whether drinking on workdays occurs during or outside of work hours or whether drinking on workdays causes problems in performance (103). It also is not possible to determine whether people who drink more prefer different shifts (25,54).

Injuries—Fatigue and impaired cognitive and psychomotor function during shift work can result in injuries. As mentioned in chapter 5, laboratory studies have shown that speed, reaction time, and accuracy decline after evening hours, suggesting that more accidents and injuries are likely to occur at night (33). Only the NIOSH study and a reanalysis of those data (97) have reported injuries by type of shift worked by nurses. **Rotating shift workers suffered more injuries than fixed shift workers.** Injury rate was not influenced by age, length of employment, or marital status. Furthermore, cuts, bruises, and punctures (mainly to fingers) were the most frequent category of injury on all shifts, and rotating nurses had significantly more such injuries than nurses on fixed shifts (97).

Family and Social Life

The NIOSH study provides some information about the effects of shift work on the family and social life of nurses. Questionnaires were administered to 1,219 full-time, nonsupervisory R.N.s and L.P.N.s in 12 U.S. hospitals; 98 percent of the nurses were female, the average age was 32.9 years, and 45 percent were married. The sample was fairly evenly distributed across four work schedules: fixed day shift, fixed afternoon or evening shift, fixed night shift, and rotating shift (generally, rotation occurred between two shifts only) (103).

Results showed that the greatest disruption of family and social life occurred for nurses on rotating shifts. Regarding degree of satisfaction with the amount of time spent with their spouses, rotating and night shift nurses were most dissatisfied. Night shift nurses reported the most interference with sexual activities, whereas nurses on rotating shifts reported the most complaints from spouses regarding their work schedules. As for amount of time spent with children, nurses on rotating shifts were the least satisfied, although afternoon and evening shift nurses reported that they assumed the least responsibility for child rearing and disciplining. Finally, rotating and afternoon shift nurses were least satisfied with the time available for personal activities, sports, and social activities (103).

EXTENDED DUTY HOURS AND GRADUATE MEDICAL EDUCATION PROGRAMS

> "Shifts" implies that there is a preset beginning and end to your work hours, however long they may be. We do not work shifts. We just work. When the work is done we can go. If that's 36 hours later, so be it. During my internship year, I routinely spent 120 hours a week in the hospital. These hours were largely devoted to menial, nonmedical tasks called scut work, a catch-all term for patient-care-related work that does not require a medical degree (i.e., inserting I.V.s, doing blood cultures, transporting patients, or scheduling tests) (31).

> I entered medical school with lofty aspirations of selfless dedication to the sick, a life of joyful altruism. Like many of my colleagues, I saw these worthy aspirations transformed into cynicism under the pressure of sleepless call nights in a pediatrics internship. My love for children became a loathing. As an intern in 1984, I worked over 135 hours a week, taking short call (until 10 p.m.) one night, long call (40 hours) the next night, and 8 hours off the next night. I felt that sleep deprivation dangerously impaired my judgment, giving me the sensation of a sleep-walking nightmare. I remembered the story of the resident in our program a few years before I came who had been so impaired by her sleep deprivation that she fell asleep at the wheel after returning from a 40- to 45-hour shift. She is now quadriplegic and will never be able to practice medicine again (62).

> I was on call for the hospital trauma and code teams eight times during a 14-week chaplaincy internship. Like the medical staff, I worked 28- to 31-hour shifts, with the most intense work during nights of little or no sleep. Like them, I alternated between adrenalin-charged highs when an ambulance or helicopter arrived and crushingly weary lows when patients died or were transferred. I counted on the calm, alert time in between to do my best work. Yet that period shrank as the shift progressed. My mind slowed after 2 a.m., and my empathy tumbled. Medical staff seemed to react the same way. Sometimes tempers frayed as the night wore on, and we all cut corners. No one was a very cheery friend for a couple of days after a night on call (117).

Graduate medical education, or residency, is formal medical education beyond the M.D. degree. This training incorporates substantial clinical experience and prepares the residents for practice in recognized medical or surgical specialties. Residents who complete this training become eligible to take the appropriate board certification examination. Resident training programs began at the Johns Hopkins School of Medicine roughly 100 years ago. In those early days, residents, as the title implies, were expected to live at the hospital, were on permanent call, and were discouraged from marrying (83,100). The first-year trainee was called an intern; now, that year is often referred to as postgraduate year one, PGY1. The training period was lengthened to include additional years—junior resident (PGY2), senior resident (PGY3), and chief resident (PGY4).[4] Some specialties have a fifth year of residency (PGY5), and others, such as neurosurgery, require 7 years. The typical resident has changed since the early days of resident training. Today the resident is older, more likely to be a woman, and more likely to have a family or other commitments outside the hospital (59).

Although extended hours for resident training date back to the early 1900s, when residents lived on hospital grounds and were on permanent call, in more recent times some residents have rotated the night shift every other night in addition to their daily duties (100). In 1975, when the Committee of Interns and Residents, a union, struck New York City's hospitals, many programs revised this requirement and allowed an on-call schedule of every third night (100). According to the Association of American Medical Colleges (AAMC):

> . . . the resident benefits by being exposed to patients throughout the course of their illnesses. This allows observation of both the natural history of the illness and the impact of the medical intervention. To experience all of the learning opportunities, the resident would have to be on duty 7 days a week, 24 hours a day. Clearly, such a schedule is unrealistic and does not recognize the possible adverse impacts of fatigue or the resident's commitments to other activities and interests. Therefore, assignment schedules for residents must be balanced between competing objectives and constraints (82).

Long hours are a necessary part of resident training. They enable residents to follow the progression of a disease and to provide continuity of care. This has been the custom and practice in postgraduate medical education for nearly 100 years. However, questions and concerns have been raised about the work schedules that have traditionally been used in resident training. It has been argued that the progression of a disease can no longer be learned in a hospital setting, since patients remain in hospitals for much shorter periods of time than they did 20 or 30 years ago (10). In addition, some maintain that long hours are a bow to tradition and an initiation into the profession—a rite of passage—that all would-be doctors must endure (6,100,112). Supporters of extended hours for residents argue that labels such as "rite of passage" are irresponsible and destructive (95). Four additional points have been identified to support the current system of extended duty hours with night call hours:

- sleep-depriving night call is a valid learning experience;
- individual idiosyncrasies, not night hours and sleep deprivation, make night call a negative experience;
- night call does not cause permanent distortion of personal and professional sensitivities; and
- quality of care is not compromised by sleep-deprived physicians (7).

It has been noted that due to the many recent advances in medical knowledge and technology, the practice of medicine is not what it was 100 years ago, when the concept of residency was created. Patients today come into the hospital sicker, and there are many more drugs and technologies available to treat them. In fact, the medical problems of patients are more severe today than they were even a few years ago (106). Prior to modern advances in medical technology and pharmacology, physicians were very limited in what they could do for patients. Physicians did their best to make patients comfortable and relieve suffering, but few diseases could be cured. There were no intensive care units, only a handful of antibiotics, and patients were admitted for observation (a practice not routinely performed today because of insurance regulations and reimbursement schedules) (16). Today, both the intensity of medical treatment and the pressure from patients for a positive outcome are higher.

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[4] Not all PGY4s are chief residents. This term refers to the resident who devises the schedule and assigns call. Only in medicine and pediatrics, and perhaps psychiatry, is the PGY4 automatically chief. In other specialties, such as pathology and surgery, usually one of the PGY5s is made chief. The other PGY5s are called senior residents.

According to one chief resident:

> In reality, a resident does not sit at the bedside and watch the progression of a disease process. After admitting a patient, the resident scurries about, drawing blood on another patient, checking lab values, or admitting the next patient. Therefore, long hours for residents provide a cheap source of labor and less real teaching benefit, with very little continuity. Furthermore, once residency finishes, rarely does a physician spend the whole night at the bedside of a patient, ready to pounce on the next development of disease. In fact, many physicians alternate call schedules with other physicians or members of their group. Very often the person who "covers" for a physician has never seen the patient before and only has a short description of the patient and the current medical problems. What happens to continuity of care in this situation? (17).

In addition, in some diseases, such as cancer, a period of weeks, months, or years is necessary to follow disease progression in patients (117). There is also the position that it is not the resident but the R.N. who is constantly at the patient's bedside; a resident may check on a patient frequently during a shift but usually does not spend more than a few minutes with the patient (101).

One legal expert rejects the notion that injuries may result because doctors are fatigued by long shifts of duty and maintains that, despite being on duty for long stretches at a time, doctors are able to sleep during slack periods (71). A chief resident argues that, although there may be times when there is a lull in the admissions process, it is during such lulls that the resident tries to catch up on all his or her other work (I.V.s, drawing blood, assessing other sick patients on the floor, etc.) (17). A resident on call at night is often responsible for the care of 40 to 60 patients, and in some busy inner-city hospitals, first-year residents may have as many as 15 new admissions each night (17). One senior resident points out that in many programs if a resident is caught sleeping during slack hours, he or she is reprimanded (62). Further, sleeping during slack periods does not take into account the likelihood that such sleep may be short, unpredictable, and repeatedly interrupted. Prior to the implementation of the new regulations of hours of work in New York, it had been reported that first-year residents averaged 2.6 hours of sleep per day (44).

Libby Zion Case

An incident that recently caused the public to focus on the issue of residents' hours was the death of a patient, Libby Zion, in a New York hospital. In 1984, Libby Zion, an 18-year-old woman, was admitted to New York Hospital-Cornell University Medical Center through the emergency room and died a few hours later. Her father, an attorney and a former reporter for the *New York Times*, charged that his daughter had received substandard care at the hands of residents. Zion was treated by an intern and a junior resident. Both of them had been on duty for some 18 hours prior to her admission.

During the 8 hours between her admission and her death, Zion was not examined by an emergency room attending physician (a physician who has completed all phases of the medical education process and whose job is teaching interns and residents), because none was on duty. Telephone discussions were held with her private attending physician, although he did not examine her in person. Further, it is argued that the intern and resident who were on duty failed to provide adequate monitoring of the patient and prescribed medications that were contraindicated in light of Zion's history of drug and medication use.

Grand Jury Findings

A grand jury convened to examine the circumstances surrounding Libby Zion's death determined that there were five contributing factors. Four factors involved supervision and treatment (85). **In addition, the grand jury concluded that the number of hours that interns and residents are required to work is counterproductive to providing quality medical care (85).** While this practice may be cost-effective for hospitals, providing them with a cheap source of labor, the corresponding cost is a diminished quality of health care (85). Physicians must be in full command of their mental faculties in order to provide proper care for patients and to continue the learning process (85). The grand jury investigation found that major medical decisions made by inexperienced physicians acting alone and unsupervised can result in medical mistakes, sometimes with fatal consequences. **The likelihood that such mistakes will occur is increased by the long hours that interns and residents must work (85).** Moreover, the wee hours of the morning are when the attending physician coverage is routinely sparse.

Hence, not only are residents tired and sleep-deprived, but they often have no senior person available for a second opinion or backup (10,31). In addition, physicians who are sleep-deprived and overworked cannot make a commitment to continuity of care (9). Accordingly, the grand jury proposed that regulations be promulgated to limit consecutive working hours for interns and residents. The grand jury failed to hand down any criminal indictments concerning Libby Zion's treatment and subsequent death, but it severely criticized the graduate medical education system in New York and made five recommendations to improve the system. **Concerning resident work hours, the grand jury recommended that the State department of health promulgate regulations to limit consecutive working hours for interns and junior residents in teaching hospitals.**

In response to the grand jury and other public and political pressures, the New York State Department of Health convened an Ad Hoc Advisory Committee on Emergency Services, which issued 19 recommendations to the health department (73). Three of these related to residents' hours:

- a 12-hour limit was to be placed on emergency room shifts;
- residents in acute care specialties not on emergency room services should work no more than 80 hours per week averaged over a 4-week period and should not be scheduled to work as a matter of course for more than 24 consecutive hours, with one 24-hour period of nonworking time per week; and
- no moonlighting would be allowed.

The commissioner of health promulgated regulations in 1988 modifying the overall organization and operations of hospitals and staffs, including supervision of residents and their hours:

- as of October 1, 1988, the emergency room shift for both house staff and attending physicians should not exceed 12 hours (there are certain exceptions if the hospital meets certain criteria); and
- as of July 1, 1989, the scheduled workweek for other house staff in designated acute care specialties should not exceed an average of 80 hours over a 4-week period. No scheduled shift should exceed 24 consecutive hours. On-duty assignments should be separated by at least 8 hours, with one 24-hour nonworking period per week.[5]

Photo credit: George Washington University Medical Center

Surgery is the specialty with the most demanding hours.

The cost of implementing these new regulations was determined to be $226 million by the New York Health Department, an increase of about 3 percent in its annual budget. The hospitals asked for additional funding. Approximately $65 million is needed for additional ancillary support —phlebotomists (technicians who withdraw blood from patients' veins), housekeepers, intravenous teams, messengers, and transport teams. It has been reported that this ancillary support work can take up as much as 50 percent of a resident's work hours (31). In some teaching hospitals, 70 to 80 percent of a resident's working hours at night have been found to be devoted to such work (4). To replace work hours lost from resident physicians, $80 million is needed for additional residents, nurses, attending physicians, and physician assistants. The balance is to cover the costs of new supervision requirements, which are also part of the new regulations. It is estimated that the cost will be $3.1 billion over the next 10 years and $5.7 billion over the next 15 years. This cost was to be distributed between the State and other third-party payers. Medicare (the Federal program for the aged and disabled) was not obligated to pay its proportional share of the cost (99). The health commissioner allocated Medicare costs to all other payers controlled by the State—Medicaid, Blue Cross, and the commercial payers (99). Blue Cross subsequently filed a successful suit to avoid payment of the Medicare costs apportioned to it (72). The commercial payers, and the State's Medicaid program, also refused to pay the Medicare share apportioned to them, leaving the system $50 to $60 million short (99).

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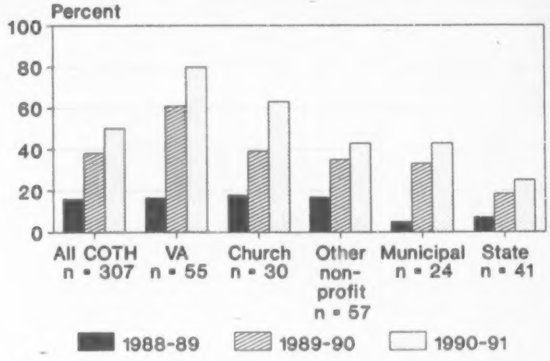
[5] There were special guidelines for surgery.

Although the intent of the regulations was to limit residents' work hours, the wording of the regulations is that no resident should be *scheduled* to work more than 12 hours in the emergency room or *scheduled* to work more than 80 hours in a 4-week period (10). It has been reported that some hospitals in New York have not fully implemented the new regulations, and some residents are still working hours in violation of them (38). Not enough time has elapsed to determine whether the regulations will have any effect on the number of malpractice incidents in New York, since a malpractice action may be filed several years after the alleged incident, and the regulations have been in effect for only 2 years. No broad-based analysis of the effect of the preexisting working hours on successful malpractice claims or quality of care was ever done (99).

While there have been some legislative and regulatory efforts involving the work hours of residents throughout the country, there have been no mandated or involuntarily enforced changes in any State other than New York (99). Massachusetts' teaching hospitals have undertaken a voluntary effort to change the working conditions of residents in that State (99). Table 8-2 discusses the current status of residents' work hours in some States. Box 8-B discusses limitations on residents' hours in Great Britain. Box 8-C explains reductions in residents' hours in New Zealand. And figure 8-1 shows the percentage of American hospitals, by ownership, that have implemented policies which set a maximum number of resident work hours.

Figure 8-1—Prevalence of Hospitals With Policies on Residents' Hours



Percent of Council on Teaching Hospitals (COTH) with hours for house staff, by ownership, 1988-91.

SOURCES: "Council on Teaching Hospitals Survey Shows Increase in Stipends, Prevalence in Housestaff Hours Policies," *Association of American Medical Colleges Weekly Report,* Oct. 19, 1990, p. 1; S. Zimmermann, "VA Leads COTH Hospitals in Resident Hours Policies," *COTH Report* 24:5, 1990.

Current Status of Graduate Medical Education Programs

As of January 1, 1990, there were 6,591 accredited resident training programs in the United States in 24 major specialties and 38 subspecialties (94). Of the approximately 85,330 residents in training programs, nearly 40 percent were in training for internal medicine, family practice, or pediatrics (94).

Regulation of Residents' Hours

Regulation of residents' hours has traditionally been under the control of the Accreditation Council for Graduate Medical Education (ACGME), which has five member organizations:

- American Board of Medical Specialties;
- American Hospital Association;
- American Medical Association;
- Association of American Medical Colleges; and
- Council of Medical Specialty Societies.

Each member organization appoints four representatives to ACGME, and the Council also has a resident representative, a public representative, and a nonvoting representative of the Federal Government. ACGME sets standards and procedures for accreditation that

Table 8-2—State Legislative Action Regarding Residents' Work Hours

California: The legislature is vigorously debating whether to control hours by legislation or through voluntary restrictions enforced by the medical schools themselves. An hours bill, calling for an 80-hour workweek with 2 days off every 2 weeks and no more than 1 day in 3 on call, was defeated in the Senate in 1990 but will be considered by the Assembly Ways and Means Committee in January 1992.

Connecticut: A bill was introduced in March 1988 but it did not get out of committee. A new version was introduced in 1991.

Hawaii: There has been no active bill in 3 years. A bill was introduced in 1988 but will not be reintroduced since the sponsor now believes that ACGME guidelines will be sufficient to control residents' hours.

Illinois: A bill was introduced in 1988 that would have required the Department of Public Health to examine residents' working conditions, but the Illinois Hospital Association lobbied strongly against it. The sponsor of the bill is considering reintroducing it in a future session.

Iowa: There are no plans to introduce legislation in this area, but in 1988 a preliminary request for a draft bill on residents' working conditions was made to the legislative service bureau.

Massachusetts: For the first time in 3 years, the legislature does not plan to consider a bill in this area. Legislators say they are optimistic about proposed regulations by the State's medical centers themselves.

Michigan: There are plans to reintroduce a bill that died in 1990. The State's hospital association contends that such legislation is not necessary, since all but three teaching hospitals already have policies on this issue.

Minnesota: The legislature has no active bill, but the topic is being overseen by two senators, one of whom may reintroduce an earlier bill if not satisfied with residents' working conditions.

Missouri: The legislature is not considering a bill during the 1991 term. A 1988 bill regarding residents' hours and working conditions died in committee.

Nevada: The University of Nevada School of Medicine at Reno, the State's only academic medical center, has executed its own hours limitations on residents.

New Jersey: The legislature has never considered a bill regarding residents' hours. The State health department discussed possible guidelines several years ago but never implemented changes.

New York: It is still the only State that has implemented rules regarding residents' hours and supervision. New York passed its law administratively in 1989, while the legislature merely passed a bill for its funding. During 1990 the State began to enforce the rules.

Pennsylvania: For the first time in 3 years, no legislator has plans to introduce a bill on this issue. No reason for this change was given.

SOURCES: Office of Technology Assessment, 1991; based on L. Page, "Resident Hours Legislation Has Slowed Down," *American Medical News*, Mar. 11, 1991, pp. 49-52.

Box 8-B—Limitations on Residents' Hours in Great Britain

In an effort to end the potential dangers posed by overworked resident physicians, the English minister for health recently announced that the Ministerial Group on Junior Doctors' Hours has developed an agreement to reduce the maximum workweek for resident physicians to 72 hours. The Ministerial Group includes representatives of the United Kingdom's health departments, National Health Service management, consultant physicians, resident physicians, and medical colleges.

The agreement calls for a short-term goal of 83 hours of work per week and a long-term goal of 72 hours of work per week for all residents, especially those in the most overworked positions. In the first step of the agreement's enactment, the government will fund the creation of an additional 200 consultant and 50 staff grade positions during 1991 and 1992. Next, the agreement will be translated into practical measures to be carried out on the local level. It calls for the immediate formation of regional committees to analyze local problems and suggest solutions.

The agreement strongly supports various types of shift work, especially in busy areas, and lists several methods for change. These include the sharing of duties by residents, additional coverage in the busiest posts, and a reorganization of work schedules to allow for more part-time doctors and time off after night duty. Examining how to maximize the use of other staff, such as nurses and midwives, will also be important.

This announcement came 2 days before the English Court of Appeal refused to dismiss a claim by a doctor who sued the Bloomsburg Health Authority for damages caused by the health authority's requirement that he work at least 88 hours a week. The doctor claimed that these hours were unbearable and that they deprived him of necessary sleep to the point of posing a danger to his own health and that of his patients.

SOURCES: Office of Technology Assessment, 1991; J. Burkhart, "England Imposes 72-Hour Limit on Residents," *Journal of the American Medical Association* 265:2742, 1991.

Box 8-C—Reduction of Residents' Hours in New Zealand

In 1985, the New Zealand Resident Medical Officers' Association was successful in reducing residents' hours from 100 per week to a maximum of 72 hours per week. In April 1988, three doctors who aided in implementing these changes spoke at a convention of the National Federation of Housestaff Organizations in Boston. They explained the reasons for this reduction, how the new hours system is structured, and the results of the decreased hours:

Rationale Behind the Reduced Hours:

- The system as it existed before 1985 produced sleep-deprived doctors who were unfairly paid and open to abuse by hospital administrations.
- Doctors who were the most sleep-deprived tended to work the longest hours and care for the sickest patients.
- Studies showed that two-thirds of residents were working over 72 hours per week and a large number were working over 90 hours per week.
- The ability to learn and the motivation to work were reduced by insufficient sleep.
- Continuity of care is already broken by changes in shifts; therefore, the question becomes one of when it is best to break the continuity, not whether to break it.
- Other professions that take responsibility for human lives and safety (e.g., airline pilots) have regulated their workers through shortened shifts.
- Generally, the night shift is the quietest, and residents' work between midnight and 8 a.m. is focused on new patients and organizing work rather than on continuing work on old patients.
- Quantity of residents' work does not equal quality.
- The benefit of shortened hours to patients greatly outweighs administrative difficulties in implementing different schedules.

Limits on Hours:

- A resident's shift may be no longer than 16 hours, and there must be an 8-hour break before the next scheduled shift can begin.
- Residents may work a maximum of 72 hours per week averaged over no more than 4 weeks.
- Emergency rooms have been targeted as high-pressure areas; thus, a resident's shift there can last no longer than 10 hours, and there must be a 9-hour break before the next shift begins.
- Emergency room residents may work a maximum of 60 hours per week, with a 50-hour-per-week average over 3 months.
- Under normal circumstances, only one shift may be worked per day.
- Adequate handover time must be provided between shifts.
- No resident shall be on duty or on call for more than 12 days without a scheduled rest period of at least 48 hours.
- Exceptions may be made on a case-by-case basis, but in considering extensions of hours, priority must be given to adequacy of rest and sleep for the resident involved.

Results:

- Residents' hours have decreased significantly: a study conducted in Auckland showed approximately 1 percent of residents working 72 hours per week; the average number of hours worked now is 54 per week, a 19 percent decrease.
- Contrary to predictions before the regulations went into effect, few problems with scheduling have arisen.
- Doctors are more awake, alert, and enthusiastic about their jobs.
- Patients have noted improved care, since they are no longer treated by sleep-deprived doctors.
- There is nothing to stop a resident from following a particular patient, but he or she does so without the ongoing responsibility for that patient's care.
- Productivity has increased, especially on the night shift.
- Residents on the night shift are expected to do more, such as keep up patient records, than they were when working longer hours.
- Nurses find the residents easier to work with, especially on the night shift.
- Residents have more time with their families and have time to pursue outside interests.

SOURCES: Office of Technology Assessment, 1991; J. Cooper, J. Mawson, and B. Swinburn, past presidents, New Zealand Resident Medical Officers' Association, excerpts from presentations given at the National Federation of Housestaff Organizations, Boston, MA, April 1988; J. Stoke, Acting Chief Medical Officer, Workforce Development, Department of Health, Wellington, New Zealand, personal communication, June 12, 1991.

apply to all training programs for residents. These standards have the force of law, since resident training programs cannot operate without ACGME accreditation (76). Under ACGME rules, resident training programs must be in "substantial compliance" with standards in order for their accreditation to continue.

The American Medical Association (AMA) House of Delegates passed two resolutions in early 1988 regarding conditions in resident training programs, which are monitored by a Residency Review Committee (RRC) in each of the 24 specialties:

- one asking each RRC to develop guidelines for residents' work hours and conditions, taking into account the intensity of the particular service environment; and
- one directing each RRC to develop guidelines regarding standards for achieving clinical competence, with a specific focus on weekly or continuous work hours, adequate time off, an average of no more than every third night on call, and one 24-hour period off every 7 days. (106).

Of the 24 specialty boards, 16 have adopted specific language addressing residents' work hours. The other eight are in areas where there is little night work (e.g., nuclear medicine, physical medicine and rehabilitation, radiation oncology, preventive medicine), thus the issues of extended hours and night call are not as great.

Accreditation Council for Graduate Medical Education

As described above, within the past few years, the ACGME has moved to revise its requirements for programs regarding supervision and hours and has directed the RRCs to introduce new standards on residents' work hours. Responses of the RRCs ranged from specific (emergency medicine mandating no more than 60 hours per week, with 12-hour shifts) to general (thoracic surgery giving the program director responsibility for ensuring reasonable in-house duty hours) to no response (general surgery and psychiatry) (see table 8-3). According to the Association of American Medical Colleges, guidelines vary because of differences in the demands and patient care requirements among specialties (102). For example, the surgical RRCs are unwilling to accept the one 24-hour period free of patient care responsibilities because of a strong belief that surgical residents should see their pre- and postoperative patients every day. On the other hand, residents in pathology have little patient contact and do not require extended hours (41).

The RRC for internal medicine, under the auspices of the ACGME, implemented new rules that took effect in October 1989 (76). Internal medicine residents must observe a maximum workweek of 80 hours averaged over 4 weeks. Residents are also to spend, on average, 1 day a week away from the hospital, and their continuous duty in the emergency room should not exceed 12 hours (76). The rules call for adequate opportunity to rest and sleep when on call for 24 hours or more, and residents should be on call no more than once every third night. In addition, limits were placed on the number of patients assigned to residents.

The American Board of Medical Specialties recently vetoed a proposal to let residents have 1 day off per week and to be on call no more than once every third night (77). Continuity of care was cited as the reason for such action. As a result of this veto, the Council of Medical Specialty Societies (CMSS), one of the other ACGME member organizations, recently failed to take a position on proposed work hours limits for residents. In a panel discussion before the CMSS deadlock vote, an AMA executive vice president argued that universal limits on hours would show Government regulators that the house of medicine was taking care of the problem of resident hours and overwork (78). According to this same AMA executive vice president, the ACGME hopes to adopt language on hours revisions that applies to all specialties, but this probably will not happen in the near future (106).

As a means of informing medical students about the work environment, including the hours requirement, at various residencies, the AMA has instituted a computerized information system called Fellowship in Residency Electronic Interactive Database Access System (FREIDA). Through FREIDA, medical students who are selecting a graduate program can determine the program's:

- average number of hours per week on duty during the first year;
- average number of 24-hour periods per month off duty;
- maximum number of consecutive hours permitted on duty; and
- whether moonlighting is allowed (93).

Table 8-3—Residents' Working Hour Requirements in the Residency Review Committee's Updated Accreditation Guidelines

Specialty	Specific hourly requirements	General guidelines	Hours not addressed
Allergy and immunology		Adequate backup should be provided if workload may create resident fatigue sufficient to jeopardize patient care.	
Anesthesiology	1 full day out of 7 away from hospital; on call no more than every third night; off-duty time should be sufficient to avoid fatigue.		
Dermatology	On average, 1 day/week should be free from hospital duties; no more than once every third night should be spent on call; rest and sleep should be provided when on call for at least 24 hours.		
Emergency medicine	On average, no more than 60 hours/week; at least 1 day/week away from hospital; no more than 12 hours/shift; at least an equivalent amount of time off between duty periods.		
Family practice	Should be adequate resident staff to prevent excessive workloads; suggest the following: on average, 1 day/week away from residency program; on call no more than every third night; ensuring backup available if there is a sudden increase in workload.		
Internal medicine	In no case should resident go off duty until proper care of patient is ensured. No more than 80 hours/week averaged over 4 weeks; on average, 1 day/week out of hospital; on call no more than once every third night and have adequate backup; should be adequate opportunity and facilities to rest when on for 24 hours or more.		
Neurological surgery		Continuity of care is most important; should have adequate backup; scheduling should avoid prolonged and excessive duties on a regular basis.	
Neurology	Should be allowed 1 day/week away from hospital; on call not more than every third night; should be adequate physician coverage.		
Child neurology			X
Nuclear medicine			X
Obstetrics-gynecology	1 day/week away from hospital; on call no more than every third night; adequate backup must be provided.		
Ophthalmology	80 hours/week limit averaged over 4 weeks; 1 day/week away from hospital; on call no more than every third night.		
Orthopedic surgery	On average, an 80-hour/week limit for direct patient care.		

Otolaryngology	Residents should not be required to perform excessively difficult or prolonged duties regularly; they should have the opportunity to spend an average of 1 day/week free of hospital duties; on call no more than every third night, except to maintain continuity of care; adequate opportunity and facilities for rest when on call for 24 hours or more.		
Pathology	On average, 1 day/week free of hospital duties; on call no more than every third night; backup should be provided when patient care responsibilities are heavy.		
Pediatrics	Resident should be on call on an average of every third or fourth night in any year; schedule should have a monthly average of 1 day/week without assigned duties in the program.		
Physical medicine and rehabilitation	No hour limits, but should have 1 day/week free from hospital duties; should be on call no more than once every third night; must recognize patient duties are not discharged at any given time.		
Plastic surgery	1 day/week off; on average, every other night off duty; annual vacation time is additional time off; adequate backup if excessive patient care could lead to resident fatigue or jeopardize patient care; support systems, including counseling to minimize stress and fatigue, should be provided.		
Preventive medicine		Resident hours on duty should be scheduled to avoid excessive stress and fatigue.	
Psychiatry	1 day/week off; on average, on call no more than once every third night; must have adequate backup.		
Radiology (diagnostic, pediatric, neuroradiology)		Residents must not be regularly required to perform excessively prolonged duties; responsibility of program director to ensure reasonable in-hospital duty hours.	
Radiology (nuclear, oncology)	Residents should have 1 day/week off; on call no more than once every third night.		
General surgery			X
Thoracic surgery		Responsibility of program director to ensure reasonable in-house duty hours so residents do not have to perform excessively prolonged periods of duty regularly.	
Urology	On average 1 day/week free of hospital duties; on call no more than every third night; adequate opportunity to rest when on call for 24 hours or more; adequate backup if work volume jeopardizes quality of patient care.		

SOURCE: Office of Technology Assessment, 1991.

It has been pointed out by one resident that some specialties, such as pediatrics, dermatology, radiology, and obstetrics-gynecology, are attracting more women. These women, as part of the old guard and as new recruits, are insisting on changes to make the current system more manageable (31). Some programs are beginning to implement a system known as night float to assist residents with hours coverage (74,104). Night float can take several forms, but basically the house staff on call will admit patients until 10 p.m., for example, and then leave the hospital when their workups are completed. At 10 p.m. the night float team comes on duty (they have been off duty all day) and covers admissions and calls until the next morning, when duties will again be turned over to the house staff. This arrangement can also be used for a day float system. It has been reported that not all programs have the funds to implement this type of system (74).

Effects of Extended Duty Hours on Residents

Research on sleep deprivation began as early as 1896 (79). In 1961 a researcher concluded that interns had little time for sleep and spent only a small proportion of their time on direct patient care (81). Ten years later, another study reported similar findings regarding the daytime activities of interns in California (42). A more recent study observed internal medicine interns and residents for 5 nights at three teaching hospitals. It determined that:

- the interns and residents admitted between three and eight patients each night;
- each house officer received 16 to 25 calls per night:
- up to 12 percent of their time was spent doing procedures such as inserting I.V. catheters or drawing blood specimens, most of which could have been done by nonphysicians;
- from 87 to 175 minutes of on-call time were spent in direct patient evaluation;
- the mean time spent on each new patient evaluation ranged from 17 to 31 minutes;
- the mean time before the evaluation was interrupted ranged from 7 to 11 minutes;
- 66 to 187 minutes per night were spent documenting new patient evaluations in the hospital record;
- the average sleep time ranged from 122 to 273 minutes; and
- the mean time before sleep was interrupted ranged from 40 to 86 minutes.

While no finding was made as to whether these house officers were sleep-deprived because of their work schedules, the researchers concluded that house officers:

- spend relatively little time in direct patient contact;
- spend considerable time charting; and
- are frequently interrupted while working and trying to sleep (59).

The results of studies examining the effects of extended hours on residents' performance are equivocal. One study noted deficits in grammatical reasoning in a group of five physicians after sleep deprivation (84). These researchers found that in another 15 subjects deprived of sleep, the ability to compensate for fatigue led to improved performance on a more complicated reading test; however, additional time was needed to maintain accuracy and complete the test. They concluded that physicians can compensate for the effects of sleep loss in the performance of both simple and complex psychomotor and cognitive functions (84). In another study, 33 surgical residents were given a comprehensive psychometric test battery (87). Results showed no differences in performance between sleep-deprived and rested residents.

A recent study of the effects of sleep deprivation on the performance of residents assigned to three services (trauma, vascular, and cardiothoracic) of a major teaching hospital failed to support the idea that sleep deprivation impairs cognitive and motor performance of residents (26). Results of this study indicated that sleep deprivation did not affect performance, as measured by a series of five psychomotor tests of visual and auditory attention, reasoning ability, spatial visualization ability, and fine motor coordination. Moreover, analysis of the correlation between certain sleep parameters (total sleep and longest period of uninterrupted sleep) and performance on each component of the psychometric test battery identified changes in performance on some tests but only insignificant effects due to sleep loss (26). The results of this study are controversial and have been challenged on the basis of the measures and experimental design used (13,14,18, 19,32,43,60,66,75,80,90,96,110).

Other studies have found decrements in some measures of performance. For example, a study in England found decreased mathematical abilities among sleep-deprived residents (57). Other studies

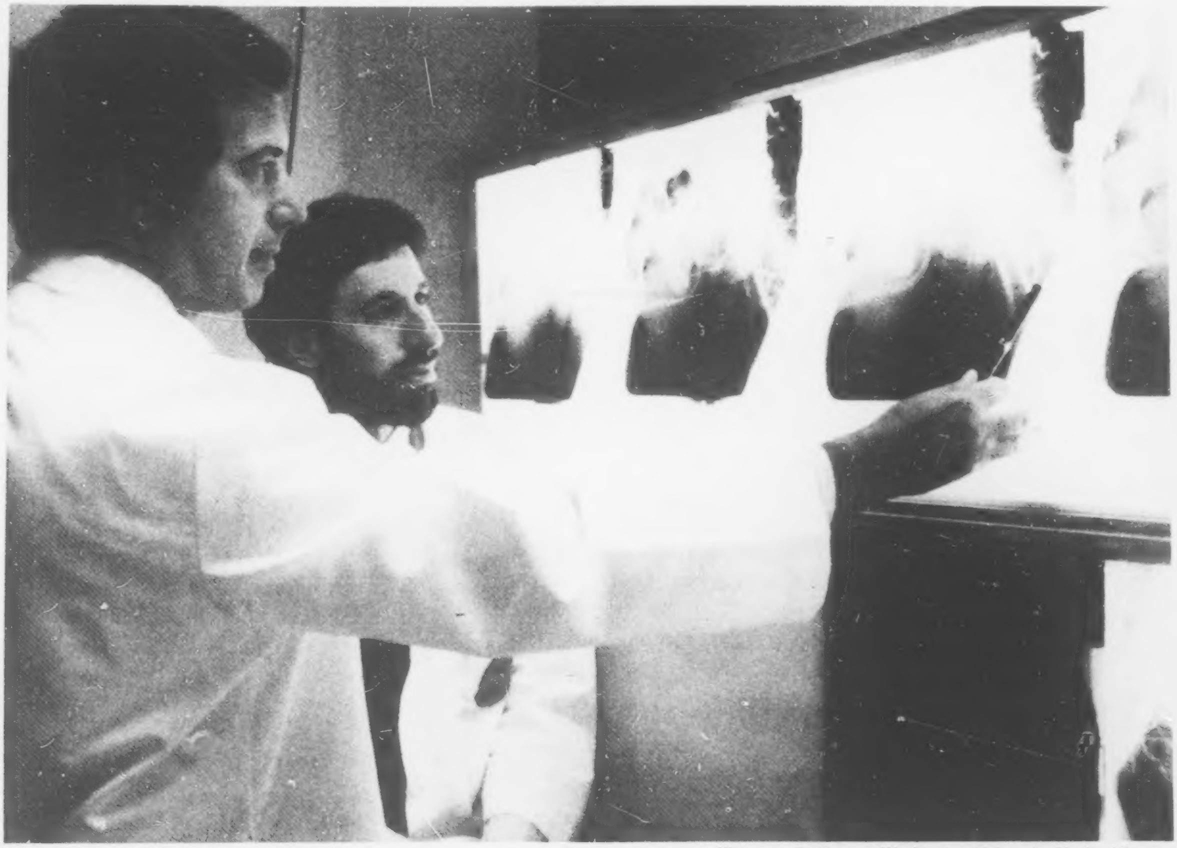


Photo credit: George Washington University Medical Center

Being able to confer with other residents and attending physicians is a critical part of graduate medical education.

involving sleep-deprived interns have found increased errors in reading electrocardiograms (EKGs) and increased time required to complete the task (36,37,111). In one of these studies, a mood scale was administered simultaneously, and results indicated that the rested interns felt more elation, social affection, egotism, and vigor and less fatigue and sadness than sleep-deprived interns (111). In another study, rested and fatigued anesthesiology residents showed a difference in response time to abnormalities appearing on a simulated monitor (28), while a study of sleep-deprived and rested interns assessing speed of information processing, decisionmaking, recent memory, and mood showed that the sleep-deprived interns had less ability to retain information, longer response latencies, and greater mood disturbances, including hostility, than the rested interns (46).

Family and Personal Consequences

There are a great number of stresses associated with graduate medical education, and working long duty hours is one of them. Cultivating and maintaining a healthy relationship with a spouse or significant other can be difficult when a resident is constantly tired. Recognizing that sleep deprivation can be a stressor, one study detected no relationship between gender and stress among internal medicine residents (56), while a separate study found that women residents reported more stress than men residents but were more likely to mobilize external support to cope with it (11).

Divorce and broken relationships often result from the stresses of residency (23). One survey of family practice residents determined that 41 percent believed their performance was impaired because of marital problems (70). Another survey found that 17 percent of residents felt that their current relationships were in jeopardy because of job stresses (53).

The outcome of pregnancy during residency for 1,293 residents and 1,494 wives of residents who served as controls was the subject of a recent study (52). It was determined that there were no significant differences in the proportion of pregnancies ending in miscarriage, ectopic gestations, and stillbirths. The rate of voluntary termination of pregnancy among women residents was three times higher than among the wives. The women residents reported working twice as many hours per week as the wives (in some residents' cases more than 100 hours per week), with pregnant residents averaging 6 to 7 on-call nights per month. Premature labor requiring bed rest or hospitalization was nearly twice as common among the residents as among the wives, as was preeclampsia or eclampsia. However, placental abruption was less likely to occur in residents. **The study concluded that there were no significant differences in pregnancy outcome between women residents and wives of male residents.**

It has been alleged that sleep deprivation is the cause of numerous automobile accidents among house staff (22,92). Anxiety and depression are common among residents (23), and several studies have documented incidents of significant depression (53,86,109). Women house staff may be at greater risk of depression than men (35), in part because residents who are mothers may have primary responsibility for child rearing when they are not on duty at the hospital. Drug dependency and alcohol dependency are also prevalent in the medical profession (116). Many hospitals are implementing programs to help "impaired physicians" cope with stress.

While many stressors may combine to affect a resident's home life, it is unclear that extended duty hours in themselves are responsible for negative consequences. No studies have focused solely on the impact of extended duty hours on home life.

SUMMARY AND CONCLUSIONS

Both nursing and resident training are characterized by shift work. Information about shift work in nursing is limited by the absence of national data on nurses' shift prevalence and career experience with shift work; few studies of the short- or long-term consequences of shift work for nurses' family and social life, health, and work performance; and few studies of the impact of various schedules on the quality of patient care. These limitations are due in part to a general lack of research attention to shift work. However, available data may also reflect prevailing assumptions about the effectiveness of pay differentials in solving shift-specific staffing problems and about the ease with which resigning nurses can be replaced, at least until recently, by a steady stream of new graduates who will be willing to work shifts early in their careers. Increased demand for R.N.s could prompt more health care administrators to examine shift work policies and to experiment with alternatives as a means of improving recruitment and retention of nurses.

While more research is needed on the short- and long-term effects of shift work on a range of nurses' health outcomes and on work performance, some adverse effects of shift work have been established. The findings of the NIOSH study associate rotating shift work with more digestive problems, more tension and stress, and a higher rate of injury. While the NIOSH study was an important examination of a number of health consequences of shift work in a large sample of R.N.s, it was cross-sectional, relied primarily on self-reported symptoms, and contained few measures of other job attributes that could be confounded with type of shift worked (e.g., workload, degree of control over work-related decisions, method of shift assignment).

Furthermore, working conditions of hospital nurses have changed since the NIOSH study was conducted in 1977. Hospital nurses today are coping with decreased lengths of patient stay and increased severity of illness as a result of prospective reimbursement of hospitals. These factors may exacerbate work stress and health problems in general, independent of shift work, or they may interact with shift work to produce extremely high stress levels among those nurses working undesirable shifts and confronting patients who require more intensive nursing care. These factors may also offset any positive effects of alternative shift schedules as a recruitment or retention strategy. More research is needed on various shift work issues, including the impact of changes in the health care system on workload, shift work, job stress, and related issues.

Graduate medical education as a training process subjects young doctors-in-training to many stresses, one of which is long hours. This has been the case for many generations of doctors. Some have begun to question the wisdom of this system, arguing that with advances in medical technology doctors have many more treatment decisions to make, and the sleep deprivation and fatigue that result from long hours can reduce the resident's ability to make timely and appropriate decisions. The Libby Zion case demonstrated how long hours may contribute to errors in patient care. This case focused attention on the issue of extended duty hours for house staff. New York has responded with limitations on scheduling of house staff hours. The ACGME has also established guidelines for reduction of residents' hours. The problem that has yet to be resolved is how these new changes will be funded in a health care economy that is financially strapped.

There have been a number of studies on extended duty hours and sleep deprivation in medical residency, but results are inconclusive. Proponents of revision argue that, despite study conclusions, it is difficult to function at maximum proficiency when one is sleep-deprived and fatigued. Almost no research has been done to determine the effect that extended duty hours have on the personal lives of residents.

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Chapter 9

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Chapter 9

Case Study: The Military

As Operation Desert Storm illustrated, technological advances have dramatically increased the ability of the military to carry out operations at night. In addition, many military situations demand that personnel engage in operations that require 24-hour manning and around-the-clock work. These operations can lead to circadian rhythm disruption, sleep loss, and other stressors (13). Many military settings that require continuous manning (e.g., command and control, medical, security, communications, ship navigation and propulsion, most transportation system operations) have civilian equivalents; others do not. For the most part, military work that has no direct civilian counterpart is performed on a continuous basis. This case study focuses on operations and work settings that are unique to the military and examines the typical duty schedules employed by the U.S. armed forces for carrying out those operations.

THE NATURE OF MILITARY OPERATIONS

An important characteristic of military activity is the context in which operations and tasks are being carried out. That context determines the tempo at which tasks are to be performed and the nature of the stressors associated with job performance. A task being performed during routine operations or in training can be very different when performed under actual or simulated combat conditions. Routine operations are those that are characteristic of peacetime and usually involve regular duty and rest schedules for continuous manning of tasks. In continuous operations, work is unceasing, but the demands on the individual are not; in sustained operations, the individual has to maintain performance for long periods (usually more than 12 hours). Sustained operations are characteristic of combat or high-alert conditions and are often characterized by sharply increased tempo (surge conditions). As a result, in sustained operations individuals have inadequate opportunity for rest, making sleep loss and fatigue limiting factors in an operation. In sustained operations, sleep loss often results from the need for an individual to perform some vital function almost continuously for an extended period of time. The amount and tempo of work (especially mental work requiring attention and concentration) and the availability of nonsleep rest periods will determine the rate at which performance degrades, with faster work tempos causing faster degradation of performance (1). Although this report is concerned with the factors limiting personnel endurance, other factors, such as having enough materiel (munitions, fuel, other supplies), equipment (servicing and repair requirements), or information (command and control decisionmaking, communication limitations, or intelligence and situation assessments) can also limit the duration of fast-paced combat or training activities.

The nature of work and rest schedules can also be altered when military units are transported to different areas. The extra tasks involved in relocation operations disrupt individual schedules, and transmeridian relocations add jet lag to other disruptions. Rapid aerial deployment of military units overseas results in jet lag, and the first day or two at sea often involves extra tasks. Relocation of forces can also occur under surge conditions (the beginning of combat operations, combat reinforcement operations, and major training exercises), in which case disruptions and stressors associated with both normal relocation and surge conditions are present.

Various disruptions of biological rhythms and stressors that lead to performance decrements are associated with these situations. Short-term desynchronization of circadian rhythms can result from changes in operations (e.g., relocation overseas) or changes in operating tempo (e.g., at the onset of hostilities or at the start of a major operation). As in shift work in the civil sector, chronic disruption of circadian rhythms may result from constantly shifting schedules and schedules that require daylight rest and night duty, such as the 18-hour duty cycle often found in submarines, the 12-hour duty cycle often used on ships, or the deployment of night-fighter teams on the battlefield. Both acute and chronic sleepiness may occur in these situations, especially under sustained operating conditions, and these, in concert with circadian disruption or on their own, can lead to degradations in performance.

Training and operational readiness exercises are a constant fixture in the military. These exercises are

Photo credit: U.S. Army

Soldiers engaging in combat exercises.

as realistic as possible, replicating as closely as possible the conditions and schedules that would be encountered during combat. Although training exercises cannot duplicate the stress and fear encountered in actual combat, they do mimic the nature and tempo of such operations. As a result, military personnel are routinely and repeatedly exposed to the various conditions described.

Activities that occur in conjunction with combat or combat training are usually marked by an increased tempo and sustained hours of duty. Another factor which can impinge on military duty hours are manpower limitations. For example, in the Navy there are manpower documents that outline the level of manning of a ship necessary for a given operation. A loss of manpower due to casualties or sickness will result in a mismatch between manpower resources and mission requirements. This situation would require that the available crew work extended duty hours to successfully complete the mission (21).

There are few specific regulations or guidelines in the military related to hours of service and scheduling. Regulations limit flight hours and length of duty for aviators in all the services; however, decisions regarding hours of duty and work schedules for all other military personnel are generally left up to commanding officers, who base their decisions on their knowledge of mission requirements and on the condition and limitations of their personnel. Under routine post, camp, and station operating conditions, in which service members can go home to their families at the end of each workday, military work schedules tend to resemble civilian work schedules. For personnel deployed in the field or at sea, work schedules tend to be about 70 hours per week. In training and operational readiness exercises, work often continues until individuals are unable to go on. The existing guidelines for rest requirements in peacetime are not binding in combat (29,38,40) and are frequently relinquished in order to accomplish the mission (3,16).

Military Tasks

A variety of tasks have to be carried out at any time, day or night, and are therefore susceptible to the effects of disrupted biological rhythms and sleep loss. Since sustained operations are integral to modern military operations, some of the most salient problems for an individual are sleepiness (inclination for sleep) and fatigue (weariness due to physical or mental exertion). Both sleepiness and fatigue affect performance. As with studies of task performance in a civilian setting, studies of the effects of around-the-clock operations in military settings have revealed that the nature of the task determines its sensitivity to circadian disruption, sleep loss, and fatigue. For example, studies of sustained operations over several days with little or no opportunity to sleep show that vigilance, memory, and cognitive task performance of infantry soldiers, tank crews, and artillery fire direction teams are degraded (13). Although most people need 6 to 8 hours of sleep daily to maintain normal levels of alertness and performance, 4 hours of sleep can offer some protection from the deleterious effects of sustained operations (13).

Tasks that require physical activity and effort (e.g., infantry marches, preparing fortifications, handling supplies) are not significantly affected by the time of day, moderate sleep loss, or other circadian disruptions (2,8,26,41) However, the perceived effort required to do a physical task is sensitive to the time of day the task is performed, with greatest fatigue perceived between 2 a.m. and 6 a.m. (11). If personnel are quite fatigued, as they often are during sustained operations, their ability to perform physical tasks can be reduced (2,10,13). Physical conditioning is important in all the services, because fit personnel have more endurance in the performance of physical tasks, even though physical fitness does not protect against the effects of sleep loss.

Military operations also involve many tasks that require constant vigilance, often under conditions not conducive to alertness. These include air defense radar and electronic surveillance, sonar, sentries, pickets, and so on. The performance of many tasks requiring vigilance (sonar operation, for example) degrades measurably after less than an hour of duty (13,24). Performance is also degraded by sleep loss and being required to work at inappropriate times during the circadian cycle, regardless of amount of rest (13,18-20,22). When vigilance is required in sustained operations, naps can be effective, especially if taken during the predawn period, from 2 a.m. to 6 a.m. (13); however, relief from the task (i.e., simple rest) and sleep are the most effective means of combating decrements in vigilance.

The operation and control of vehicles is also a common characteristic of military operations. Studies of the effects of fatigue on the performance of aircraft pilots indicate that physical coordination seems little degraded, even in conditions of extreme sleepiness (15); however, judgment degrades fairly quickly with the onset of fatigue (7,12,42). This effect is compounded when tasks are performed near the nadir of the circadian alertness cycle. There are regulations to guide aircraft operations (described later) but no crew rest guidelines for land or water vehicle operators. The use of pharmacological agents to enhance performance in aircraft operations, especially after long flights or during sustained operations, is being investigated (5).

The performance of other types of tasks associated with military operations, such as the maintenance, preparation, and operation of equipment (e.g., weapons systems, communication systems, construction equipment), may also be affected by circadian, fatigue, and sleepiness factors associated with time and duration of duty. As with the other tasks described, this is especially true in the case of sustained operations (13,23).

Finally, the task of commanding, which involves judgment and planning, is vulnerable to performance degradation caused by sleep loss and biological rhythm disruption. In fact, judgment is usually the first faculty to be degraded, and it is a very difficult one for the individual to monitor (2,9,12). There are no regulations or guidance regarding the duty hours associated with command. Leaders and command and control personnel generally stay awake and are involved during continuous and sustained combat operations to see to their responsibilities. However, since effective leadership depends on unimpaired judgment, and fatigue, sleep loss, and other biological rhythm disruptions impair judgment, avoiding or minimizing such effects is critical to successful combat leadership and command and control. The implementation of sleep discipline plans, a relatively new military innovation, is critical for combat leaders (14).

OPERATIONS REQUIRING 24-HOUR MANNING

Military operations that could be affected when personnel are exposed to biological rhythm disruption or sleep loss include combat operations (immediate involvement in fighting) and combat support (supply, communications, or medical aid), as well as combat training exercises. This includes all aspects of land combat (in-place, reinforcement, and expeditionary), support logistics operations, air operations (tactical and logistic), high-readiness operations of strategic forces, and the operation of naval vessels at sea. The most salient disruption in such cases is fatigue and sleep loss, exacerbated by various kinds of stress. Circadian disruption can also occur in combat operations: events such as strikes and assaults are often planned for the time at which the enemy is expected to be least effective. Momentum is very important in offensive operations (especially in land combat), and sustaining it for days or weeks entails many human endurance problems. Also, some element of surprise is always desirable in combat actions. The conduct of extended combat operations (over days and weeks) tends to be more effective if there is no discernible routine to the action. The need to carry out operations in which routines and predictability are minimized will have a negative effect on personnel duty-rest schedules.

Army Operations

With the exception of Army Aviation, there are no specific guidelines for work schedules and duty hours for most Army activities and operations. In their planning of operations, it is the responsibility of individual commanders to ensure that the personnel under their command are rested and fit for duty.

Deployment

Most military units are based in the United States; military units outside the United States are usually deployed for some limited period and then replaced. This deployment is usually scheduled well in advance. Individual jet lag can best be mitigated by allowing for recovery periods at the destination.

Surge deployment is usually in response to some new military requirement (e.g., the need to show force to support foreign policy in a time and place of tension) and is done on short notice. It usually involves transmeridian movement by aircraft, so jet lag effects would be present. The requirement to pack up, load, unload, and set up at a destination causes additional transient disruptions. Since these temporary tasks are not part of what is usually thought of as combat or mission tasks, they are not included in the planning of operations (35,38).

Reinforcement

Reinforcement is adding more personnel and equipment to units already deployed. Usually, reinforcement would be more urgent than relocation and would require new personnel to begin operations immediately on arrival at the same operating tempo as existing forces. Reinforcement is most likely to occur under surge conditions. The same disruptions in biological rhythms that would be encountered during initial troop deployment could also occur during reinforcement operations.

Special Operations

Special operations are difficult to characterize, given their inherent irregularity and classified nature. Special forces can be subjected to unpredicta-

Photo credit: U.S. Army

Helicopter pilot wearing night goggles.

Table 9-1—Crew Endurance Guide for Flight Operations, U.S. Army

Time period (hours)	Maximum duty period (hours)	Maximum flight time (hours)	Environmental factor	
24	16	8	Day	1.0
48	27	15	Day contour/low level	1.3
72	37	22	Instrument	1.4
168 (7 days)	72	37	Night	1.4
720 (30 days) (peacetime)	288	90	Day NOE	1.6
720 (30 days) (mobilization)	360	140	Night terrain	2.1
			Night vision devices	2.3
			Chemical MOPP	3.1

EXAMPLE: The stress and fatigue experienced in 1 hour of day nap-of-the-Earth (NOE) flight (e.g., extreme low-level, contour flight) is equal to 1.6 hours of standard day flight. If a crew member flies day NOE in chemical mission-oriented protective posture (MOPP), the larger factor (3.1) will be used. The flight time shown in column 3 will be adjusted by the factors in column 4.

SOURCE: U.S. Department of the Army Regulation AR 95-3, *Aviation, General Provisions, Training, Standardization, and Resource Management.*

ble and unanticipated requirements and must respond on short notice to anything from military search and rescue missions to counterterrorism. Frequently these situations require rapid deployment and the crossing of time zones. Planned or programmed duty-rest schedules usually are difficult to implement in such situations (17). Special operations forces tend to train at a continuous operations tempo, interspersed with periods of sustained operations, combined with relocations on short notice (often involving transmeridian travel).

Combat

For planning purposes, Army regulations specify that combat personnel (those doing the fighting) should have 6 hours each day for rest (35). In actual combat situations, as in the reinforcement and special operations outlined above, the nature and scheduling of rest periods would be dictated by the conditions of the moment.

Army Flight Operations

Army regulation 95-3 (36) governs scheduling limits for flight operations of both fixed-wing and rotary aircraft. These regulations provide guidance for duty period and flight time limits for air crews (table 9-1). The limits are adjusted for the conditions under which the operations occur. For example, flying 1 hour at night is considered the same as flying 1.3 hours during the day. In addition, the regulations recommend that commanders consult the unit's flight surgeon and aviation safety officer when setting limits for specific operations or time periods.

Air Force Operations

Tactical and Transport Forces

Air Force tactical and transport flight operations are guided by a number of regulations that provide requirements for scheduling (27-29,32,33). Tactical forces engage in air combat, support land warfare (close air support, interdiction of enemy supply lines, surveillance), and consist largely of fighters, bombers, and helicopters. Transport forces carry personnel and materiel from the United States overseas and from overseas supply depots to more remote distribution points. These aircraft consist primarily of tanker and transport craft. Exercises are conducted routinely to provide experience with various combat and readiness scenarios.

Rest and flight duty limitations for all personnel who operate Air Force aircraft are delineated in several Air Force regulations (29-31,33). These regulations specify:

- maximum allowable flight duty periods for basic and augmented crews,
- maximum monthly and quarterly flying hours for aircrews,
- minimum crew rest periods, and
- conditions necessary to waive the requirements.

The maximum allowable flight duty period is the maximum number of hours crew can fly in a certain type of aircraft in a 24-hour period (table 9-2). Total flying time for tactical forces is limited to 75 hours per 30 consecutive days and 200 hours per 90 consecutive days (31). A minimum rest period of 12 hours is mandated between flights and must include 8 hours of uninterrupted, continuous rest. If a crew

Table 9-2—Maximum Flight Duty Periods, U.S. Air Force

Aircraft	Basic aircrew	Augmented aircrew
Fighter, attack or reconnaissance		
Single control	12	
Dual control	12	16
Bomber or reconnaissance		
Single control	12	
Dual control	24	30
Transport	16	
Sleeping provisions	16	24
Tanker	20	
Sleeping provisions	20	30
Trainer	12	16
Rotary wing (no automatic flight control system)	12	14
Rotary wing (automatic flight control system)	14	18
Utility	12	18

SOURCE: U.S. Department of the Air Force Regulation AFR 60-1, *Flight Management.*

member is interrupted and cannot get 8 hours of rest, he or she must be afforded 8 more hours of uninterrupted rest plus reasonable time for other activities (e.g., dressing, eating, traveling) (31). These regulations also specify that the relationship between crew rest and limitations on flight duty hours be considered when planning and scheduling missions. For transport crews, total flying time is limited to 125 hours per 30 consecutive days and 330 hours per 90 days (33). Based on the timetable established for a deployment operation, a unit's commander and flight surgeon may develop a schedule prior to departure that will adjust crew members' body clocks (6). Finally, the regulations authorize commanders to waive maximum flight duty periods for high-priority missions and during impending or actual hostilities.

Nonflight Air Force support units (airfield operations, communications facilities, logistic support, aircraft repair) are generally operated on a continuous basis. The factors affecting their operating tempo and conditions are similar to Army combat support activities.

Maximum limits on duty hours for all Air Force personnel (i.e., flight and nonflight) in a wartime setting have been set at 247 hours per month (10 hours per day, 6 days a week) during continuous operations and 309 hours per month (12 hours per day, 6 days a week) for a maximum of 30 days during sustained operations (6).

Strategic Forces

Strategic forces are the nuclear deterrent intercontinental bomber and missile forces. These forces operate on a routine carefully designed and controlled to sustain operations without decrements in performance. The primary concern is to ensure that personnel with access to nuclear weapons are reliable and can carry out their duties without impairments to their judgment or performance.[1]

Flight operations are guided by the general Air Force flight regulations previously described and others specific to strategic forces operations (30). These regulations include the requirement that, when possible, missions with late-night departures (which cause the crew to fly through normal sleeping hours and to rest during normal working hours) be scheduled for less than maximum duty periods. Also, the regulations stipulate that crew members who cross more than three time zones on route to a permanent location should normally not be required to perform any additional flight duty for the first 48 hours after arrival at their destination (30).

The crews manning intercontinental ballistic missile silos are on alert duty for 24-hour periods. Regulations stipulate that the minimum rest-sleep period for each crew member is 6 hours (34). In general, these crews are on duty every third day. When relieved of duty, a crew member will have a minimum rest period of 12 hours.

Navy Operations

Nonshipboard operations are similar to Army or Air Force nonflight operations as far as scheduling is concerned. Ships in port maintain duty-rest schedules very much like those of activities ashore, nominally modeled on a 40-hour workweek, with limited personnel standing watch around the clock (see later discussion). When deployed, there is a transition to the at-sea routine, which typically consists of a 70- to 80-hour workweek (38).

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[1] Each service has a tightly controlled Personnel Reliability Program which covers all persons who have duties involving access to nuclear weapons (from the technicians who put them together and do maintenance on them, to the crews who prepare them to fire or be dropped, to the crews who fire or drop them). The program involves background checks, regular reviews by medical officers and commanders, and annual certification of behavioral reliability for each person in the program.

Shipboard operations require that some tasks be performed on a continuous basis. Unlike land-based facilities, where there may be local resources to draw on, each ship must be entirely self-sufficient. The crew must not only carry out the mission of the ship but also perform all housekeeping and maintenance tasks associated with it. Thus, normal operations on a ship have the character of continuous operations. Typically, jobs on board ship are divided into two types. Work that is general in nature, such as maintenance and repair tasks, is routinely carried out on board ships at sea using a 12-hour shift schedule (12 hours on, 12 hours off) (38,39). Tasks that require an individual to operate a specific piece of equipment or be at a specific station (sonar, radar, communication operators, engine room personnel) are manned using a watch schedule. A person who is on watch is at his or her station for a certain period of time and is then relieved by the next person standing watch. The specific watch schedules for submarines and surface ships are described later; however, they often result in personnel constantly changing the hours they are active and the hours that they are sleeping. Thus, these schedules cause substantial circadian disruption. A study that examined the effects of watch schedules on merchant ships has shown that these schedules are associated with sleep disturbances, decreased alertness, and decreases in measures of performance (4,25).

Several conditions of readiness modulate a ship's work schedule. Condition I Battle Readiness is the equivalent of sustained operations; all systems are manned and operating, and no maintenance is conducted except maintenance associated with keeping watch and urgent repairs. The crew does not have any rest period and is expected to be able to endure Condition I for 24 continuous hours. Condition II Battle Readiness means that required operational systems are continuously manned and operating, but the crew does have 4 to 6 hours of rest per person per day. Urgent preventive maintenance and support functions are carried out. Other conditions are Wartime Cruising Readiness, Peacetime Cruising Readiness, and Inport Readiness, as well as readiness for specific types of ships (e.g., mine countermeasures, amphibious operations, supply ships) (21).

Submarines

The essence of submarine operations is to remain undetected, and that, in turn, depends on maintaining a very high state of vigilance. Undersea is a significantly more hostile environment than the surface, with much less time available to respond to mechanical problems that arise, so propulsion and control (and related systems) vigilance must be high and sustained as well. There are two types of submarines, ballistic missile and attack submarines. Ballistic missile submarines carry nuclear missiles and operate in a mode that is essentially a combination of independent operations and Air Force strategic forces operations. Their task is to remain in their assigned area, undetected, and be ready to launch their missiles if so ordered. Attack submarines have more varied tasks, including defense of a group of surface ships, information gathering, and attacks on enemy shipping. Both ballistic and attack submarine operations at sea use 18-hour watch schedules, consisting of three sections of personnel rotating 6 hours on, 12 hours off. Generally, the 6-hour on period is the time an individual is engaged in his or her specific job (e.g., sonar operator, radio operator). The 12-hour off period is used for sleep and rest as well as other activities, including meals, maintenance, training, and administration. Typically, a crew member averages 4 hours of sleep during an 18-hour cycle, depending on the tempo of the operations, training, and maintenance, with each sleep period occurring 6 hours earlier than the previous one (37). Analogous to a rotating shift schedule, watch scheduling results in individuals who will always be active and sleeping at different times of the day and whose sleep periods will generally be shorter than normal.

Surface Ships

Naval surface ships include combat vessels and supply ships. During routine operations at sea, the watch schedules depend on the size of the crew, which will determine how many sections of personnel are used. Usually, schedules are based on duty cycles of 12 hours (two sections with 6 hours on watch, 6 hours off; three sections with 4 hours on watch, 8 hours off), 16 hours (four sections with 4 hours on watch, 12 hours off), or 18 hours (three sections with 6 hours on watch, 12 hours off). The on period is the time when the crew member is engaged in a specific job, while off time is divided among other tasks, eating, and sleeping. Crew members on surface ships average 6 hours of sleep per 24 hours (37), and their watch schedules require them to constantly change their hours of activity and rest.

Supply ships replenish combat ships with fuel, foodstuffs, parts, and munitions. Replenishing supplies while at sea can upset the duty-rest routine of a large portion of the crew on the ship being supplied because of the extra tasks required (e.g., tending lines, standing extra lookout watches, stowing supplies). The frequency of underway replenishment depends on the activity of the ship, but replenishment every 3 or 4 days is not uncommon, principally because combat ships are maintained as nearly full of fuel and other supplies as possible all of the time.

Under combat conditions, when the crew of a ship is at general quarters for extended periods, acute fatigue can become a problem. In combat there is a constant threat of attack from the air, submarines, and other ships. The entire crew is on duty without relief in order to carry out all of the defensive and other operations required. Activity under these conditions is fast-paced and continuous; sleep and rest are often sporadic and irregular.

Aircraft carrier operations involve the same tasks as other combat surface vessels but include tasks involved in flight operations. These tasks include moving aircraft around, preparing them for flight, operating catapults and arresting gear, air traffic control, and all other operations that support air combat mission preparation and control. Generally, aircraft carriers carry enough personnel to make up one complete shift to operate the equipment and do the tasks required to conduct flight operations. During continuous flight operations, this shift is split; thus, flight operations do not involve the kind of rotating work-sleep schedules so common on other ships. Crews ordinarily work about 14 to 16 hours each day; during periods of sustained activity, they may work nearly continuously (20 hours or so each day) for several days. Operating for extended periods at general quarters is even more disruptive aboard an aircraft carrier than other surface combat ships because of the far greater amount of movement of men and materiel from one part of the ship to another in conducting flight operations. Crew members are effectively in a sustained operations mode (none returns to sleeping quarters).

Table 9-3—Maximum Accumulated Individual Flight Times, U.S. Navy

	Maximum hours		
Aircraft	30 days	90 days	365 days
Single-piloted	65	165	595
Multipiloted (pressurized, ejection seat)	80	200	720
Multipiloted (nonpressurized) ...	100	265	960
Multipiloted (pressurized)	120	320	1,120

SOURCE: U.S. Department of the Navy, "Military Planning and the Impact of Circadian Rhythms on Military Operations," briefing materials provided to D. Liskowsky, Office of Technology Assessment, Washington, DC, 1989.

Flight Operations

The Navy's flight crew regulations are similar to the Air Force's in that they may not constrain operations in wartime (40). These regulations specify maximum hours of flight time: 6.5 hours per day for single-seat aircraft and 12 hours for other aircraft. They also specify that flight personnel should not be assigned to flight duty on more than 6 consecutive days. The regulations indicate that 8 hours of sleep time should be made available every 24-hour period and that flight personnel should not be scheduled for continuous alert or flight duty (which requires the person to be continuously awake) for more than 18 hours. If the 18-hour rule is exceeded, 15 hours of continuous off-duty time must be provided to the individual. The maximum number of accumulated hours of flight time for various aircraft is also specified (table 9-3). Finally, the regulations state that if the tempo of operations requires an individual's flight time to exceed any of the guidelines, that person should be closely monitored and specially cleared for flight by the commanding officer, with the advice of the flight surgeon. In situations where jet lag might occur (changing local sleep-awake periods, transmeridian flights), flight crews are not grounded, but the guidelines suggest that closer observation of the individuals by the flight surgeon may be warranted (37,40).

Marine Corps Operations

Amphibious Assault

The opposed landing (coming ashore against armed opposition) is the essence of Marine Corps operations. It is a very intense period of sustained operations that changes to continuous operations in a day or two. Although seas and tides are important factors in the timing of amphibious assaults, most operations are planned to begin before dawn, when the enemy is expected to be least vigilant and effective. As with Army combat operations, there are no specific guidelines regarding duty hours for Marine combat units. The planning of operations and the monitoring of the condition of troops are left to the discretion of commanding officers. The Marine air forces, which provide air support for amphibious assaults and other Marine ground operations, are governed by the same flight crew duty-rest cycle regulations as Navy flight crews (40). Under actual combat conditions, the limitations on flight hours imposed by these regulations may be exceeded. For example, in the case of amphibious assaults, which tend to be fairly short in duration, these limits may be exceeded for the first 36 to 48 hours of the operation.

SUMMARY AND CONCLUSIONS

The nature of many military operations requires that personnel be engaged in activity at all hours and often for extended periods of time. Within the context of these operations, personnel are required to carry out a variety of tasks, the performance of which can be degraded as a result of disruptions in biological rhythms, sleep loss, fatigue, and other factors. Decisions concerning the schedules used and the duration of duty are generally left to commanding officers, who base their judgments on their knowledge of the limitations of their personnel under various conditions. There are few specific regulations or guidelines in the military related to hours of service and scheduling. An exception is the regulations that direct flight operations in all services. These regulations specify maximum allowable hours of flight duty and may include stipulations regarding transmeridian flight, minimum necessary rest periods, and the scheduling of flight operations. In the Navy there are specific guidelines, which have a long-standing tradition, for the scheduling of watches on board ships. They require that personnel standing watch constantly vary their hours of activity and sleep, which results in a constant state of circadian desynchronization.

Finally, the overriding priority in all military operations is the successful completion of the mission. As a result, regulations regarding duty hours are generally waived in wartime operations. There may be battle circumstances in which all available forces are needed, even if they will not be functioning at optimal levels and even if their effectiveness in the near future will be even more degraded. Decisions concerning the disposition and activities of personnel are guided by the demands of a given situation, and the effects of performance decrements due to biological rhythm upset, fatigue, and other factors may be accepted rather than mediated in some wartime circumstances. A better understanding of those decrements and their effects will ultimately aid military commanders in balancing the various factors that go into making such decisions.

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Appendixes

Appendix A

International Regulation of Shift Work

Policies and regulations on shift work vary widely from country to country. This appendix examines regulation of wages, hours, rotation schedules, and rest periods in other nations. It also reports on special provisions for women and specific industries (e.g., the transportation industry), as well as social support services for night and shift workers. The International Labor Organization's (ILO) global role in encouraging and coordinating protective legislation is also discussed.

An estimated 7 to 15 percent of the work force in industrialized countries is engaged in some form of night work (6). As of 1988, 13.3 percent of workers in France, 5.4 percent in Sweden, 12.5 percent in Switzerland, and 15 percent in Norway engaged in some form of night work.

The degree to which various countries address the needs of their shift workers via regulation varies. Most governments regulate basic matters such as extra pay for night work. Some governments, however, address the physiological dangers of night and shift work directly. For example, Bulgarian laws prescribe reduced hours for night work on the assumption that "the performance of night work is harmful to the human organism, as a result of changes in the normal cycle of the physiological functions in the human body which are caused by its performance" (3). In Bolivia, the statutes reflect a belief that "night work is contrary to man's physiology, exhausting and dangerous to the health if practiced as a normal system" (3). In France, the laws allow someone who has been working at night for a long period (5 years' continuous night work or 10 years total) to receive top priority for openings on the day shift. In Angola, a person with medical problems gets a similar priority for openings on the day shift (6). Other countries make different provisions, outlined later in this appendix.

Special arrangements and regulations for shift workers are by no means universal, however. Often, regulations do not address all the needs of shift workers, and when they do, efforts to meet those needs are rarely systematic. Actual response to the needs of the workers depends on a variety of external factors. For example, in some countries the cost of enacting and enforcing protective legislation could be greater than the benefit to the workers. This may be particularly true in less-developed countries, where strict regulations on shift work could slow needed economic development. In other countries, however, where high wages make automation a viable option in some sectors, shift work could be reduced with little economic impact. In still other countries, economics could necessitate the hiring of more shift workers; this is the present position of France and England (6).

In some cases, regulation of shift work did not stem from conscious attempts to address the specific problems of night or other shift workers, but from some other labor initiative, such as a general campaign to reduce work hours. In some countries, such as the United States, the legal framework may make it difficult to enact a national standard. In the United States, many of the regulations fall under the jurisdiction of the States, not the Federal Government (11). The issue of a national standard is unresolved because there has never been an attempt by the Federal Government to test the Constitution on this point. In other countries, traditional methods of dealing with labor problems without government intervention are firmly entrenched. In the United Kingdom, for example, labor problems have been solved through collective agreements, and the government has traditionally not regulated such areas, including shift work. Finally, the absence of national regulation of shift work in the majority of countries can be because "special rules for shift work exist as part of plant agreements applicable to a particular region or branch of industry" (10). This is true in Canada, which has regulations on the provincial level.

The end result is that some countries have extensive regulation and support services for shift workers, and others have virtually none. In a few nations, there are extensive laws that cover a wide range of issues, including leisure facilities, housing facilities, and retirement programs for workers. For the most part, though, regulations dealing with nonstandard work schedules are limited to hours and wages. The most common regulation seems to be increased pay. The second most common seems to be fewer hours.

Few countries have no guidelines. Of the countries analyzed here, six—China, the United States, Canada, the Dominican Republic, Tunisia, and Nigeria—have no national regulation of night or shift work (apart from a few specific industries such as the transportation sector). As noted before, however, regional regulations can exist in the absence of national regulations; therefore, absence of national regulations does not necessarily mean absence of all regulations. Table A-1 displays regulations of work, rest, and shift work in 49 countries.

Special night work regulations for certain industries or segments of the population are common. In the United States, for example, there are Federal regulations governing some sectors of the transportation industry (e.g., airlines and marine shipping). Transportation is regulated in many other countries, including Greece, Ireland, Austria, Japan, Spain, and Turkey. Agriculture, on the other hand, is often specifically exempted from shift work regulation, as it is in New Zealand, Norway, Finland,

Table A-1—Regulation of Work, Rest, and Shift Work in 49 Countries

	Argentina	*Australia*
Major source of regulation[a]	Legislation	Collective bargaining; mandatory government arbitration
Maximum daily hours[b]	8, but may be exceeded so long as weekly total does not exceed 40	No general regulations
Maximum weekly hours[c]	48	38-40, but may be averaged over a period exceeding a week
Rest during the day[d]	For meals (at home if possible) and for duties such as feeding of child	Usually 0.5 hour if work exceeds 5 hours
Minimum rest between days or shifts[e]	12 hours	Usually 10 hours
Minimum weekly rest[f]	No work from 1 p.m. Saturday to midnight Sunday	1.5 to 2 days
Shift work (except night work)[g]	Maximum limits on daily and weekly working hours waived, but must average no more than 8 hours/day and 48 hours/week over 3-week period	Maximum of 11 shifts in 12 days, usually extra pay
Night work only[h]	Maximum of 7 hours/night	Extra pay, RWC[k]
Data valid as of[i]	1984[j]	1986[j]
	Austria	***Belgium***
Major source of regulation	Legislation	Legislation
Maximum daily hours	10 (8); RC[m]	8, but 10 hours/day if worker is unable to return home every day; maximum of 11 in special cases (including shift work)
Maximum weekly hours	50 (40); RC	40 (50 for shift work; up to 65 hours above average)
Rest during the day	0.5 hour if work exceeds 6 hours	No general regulations
Minimum rest between days or shifts	11 uninterrupted hours	No general regulations
Minimum weekly rest	36 uninterrupted hours, except for shift work	24 hours on Sunday
Shift work (except night work)	Maximum of 2 consecutive shifts; maximum of 40 hours/week, averaged	Maximum of 11 hours/day; maximum of 50 hours/week; maximum of 40 hours/week for 13 weeks
Night work only	2 to 6 extra vacation days per year; special pension; extra breaks	Generally prohibited; exceptions up to 11 hours/day; up to 12 hours/day for work that cannot be disrupted; maximum of 50 hours/week so long as it averages 40 hours/week or less over 13 weeks
Data valid as of	1986[j]	1986[j] [l]
	Brazil	***Bolivia***
Major source of regulation	The constitution; legislation, which may sometimes be overridden by collective bargaining	Legislation
Maximum daily hours	10	8
Maximum weekly hours	(48)	(48); RWC
Rest during the day	No general regulations	At least 2 hours; no more than 5 hours of work at a stretch
Minimum rest between days or shifts	No general regulations	No general regulations
Minimum weekly rest	1 day/week	Work prohibited on Sundays
Shift work (except night work)	Extra pay	For "team work," hours averaged over 3 weeks; must meet normal daily and weekly limits
Night work only	Extra pay; 52.5 minutes are equal to 1 hour of day work	Maximum of 7 hours; extra pay; RWC
Data valid as of	1977[j]	1980[j]

	Bulgaria	***Canada***
Major source of regulation	Legislation	Provincial legislation
Maximum daily hours	Maximum of 8.5 for 5-day workweek; maximum of 8 for 6-day workweek; maximum of 6 days before rest days; RC	8
Maximum weekly hours	Maximum of 42.5 for 5-day workweek; maximum of 46 for 6-day workweek; RC	48 (40)
Rest during the day	0.5 hour	No general regulations
Minimum rest between days or shifts	12 uninterrupted hours	No general regulations
Minimum weekly rest	48 uninterrupted hours for 5-day workweek; 24 uninterrupted hours for continuous-process workers, shift workers, and 6-day workweek	1 day
Shift work (except night work)	See above; no consecutive shifts, regular rotations	No general regulations
Night work only	For 5-day workweek, maximums of 7 hours/night and 35 hours/week; for 6-day workweek, maximums of 6 hours/night and 36 hours/week	No general regulations
Data valid as of	1986[j]	1986[j]

	China	***Colombia***
Major source of regulation	Legislation	Legislation
Maximum daily hours	8	Maximum of 8; not applicable to shift work
Maximum weekly hours	48	Maximum of 48; maximum of 56, when necessary, for shift work
Rest during the day	Required but unspecified; extra hour for nursing mothers for feeding	Required but unspecified
Minimum rest between days or shifts	No general regulations	No general regulations
Minimum weekly rest	No general regulations	Paid rest on Sundays
Shift work (except night work)	No general regulations	Extra pay; may work over the daily and weekly limits up to 56 hours/week; may work on Sundays, but must receive advance notice and must receive a compensatory rest day
Night work only	No general regulations	Extra pay; RWC
Data valid as of	1978[j]	1976[j]

	Czechoslovakia	***Denmark***
Major source of regulation	Legislation	Collective agreement
Maximum daily hours	9 (8)	Usually 8, by national collective agreement
Maximum weekly hours	46 (42.5); may be averaged; RC	Usually 39
Rest during the day	0.5 hour if work exceeds 5 hours	No general regulations
Minimum rest between days or shifts	12 uninterrupted hours; 8 for shift workers; RW[m]	11 hours/day; RC
Minimum weekly rest	32 uninterrupted hours	1 day
Shift work (except night work)	Maximum of 7.5 to 8.5 hours/shift, depending on circumstances; maximum of 56 hours/week for continuous shift workers; minimum of 8 hours rest between shifts	Earn 3 extra hours of leave every 40 hours of work; minimum of 8 hours' rest when changing shifts
Night work only	Extra pay; RWC	No general regulations; RC
Data valid as of	1986[j]	1986[j]

	Dominican Republic	***Ecuador***
Major source of regulation	Legislation	Legislation
Maximum daily hours	8	Maximum of 8, unless 9 hours are worked to free Saturdays; RC
Maximum weekly hours	44; not applicable to shift or continuous work	44; RC
Rest during the day	No general regulations	No general regulations
Minimum rest between days or shifts	No general regulations	No general regulations
Minimum weekly rest	24 uninterrupted hours on Sundays; usually no work permitted on Saturday afternoons	No work permitted on Sundays
Shift work (except night work)	No general regulations	No general regulations
Night work only	No general regulations	Extra pay; RWC
Data valid as of	1986[j]	1978[j]

Table A-1—Regulation of Work, Rest, and Shift Work in 49 Countries—Continued

	Finland	*France*
Major source of regulation	Legislation	Legislation
Maximum daily hours	8; 9 if weekly total is less than or equal to 40	10
Maximum weekly hours	48 (40); RC	48 (39); must average to maximum of 46 hours/week over 12 weeks; RC
Rest during the day	1 hour if work exceeds 7 hours, except for shift work; RC	No general regulations; RC
Minimum rest between days or shifts	12 hours	No general regulations; RC
Minimum weekly rest	30 uninterrupted hours; RC	24 hours on Sundays
Shift work (except night work)	No general regulations	No consecutive shifts; maximum of 35 hours/week averaged over a year
Night work only	Prohibited	No general regulations; RWC
Data valid as of	1986[j]	1986[j]

	Germany
Major source of regulation	Legislation
Maximum daily hours	10 (8); RC
Maximum weekly hours	48; RC
Rest during the day	0.5 hour if work exceeds 6 hours; RWC
Minimum rest between days or shifts	11 uninterrupted hours; RC
Minimum weekly rest	24 hours, usually on Sunday; RC
Shift work (except night work)	May work up to 16 hours once every 3 weeks to change shift, but must be granted uninterrupted rest of 24 hours at least twice during the 3 weeks; RC
Night work only	No general regulations; RW
Data valid as of	1986[j]

	Greece	*Hong Kong*
Major source of regulation	Legislation	Legislation
Maximum daily hours	8; 9 for 5-day week	No general regulations; RWC
Maximum weekly hours	48 (40); 56 for shift work	No general regulations; RWC
Rest during the day	No general regulations	No general regulations; RWC
Minimum rest between days or shifts	No general regulations	No general regulations
Minimum weekly rest	24 hours, usually on Sundays	24 uninterrupted hours/week; RWC
Shift work (except night work)	Hours averaged over 8 weeks, must conform to normal limits	No general regulations
Night work only	Extra pay; RWC	No general regulations; RWC
Data valid as of	1986[j]	1981[j]

	Hungary	*India*
Major source of regulation	Legislation and collective bargaining	Legislation, but with wide powers to make exceptions by the state governments
Maximum daily hours	12	9, 10.5 including rest time; RC; not applicable to shift work during change of shifts
Maximum weekly hours	40 for industry and government; 42 for the rest of the industries	48; RC
Rest during the day	One 20-minute break/day	At least 0.5 hour/5 hours
Minimum rest between days or shifts	11 uninterrupted hours	No general regulations
Minimum weekly rest	1 day/week mandatory; 2 days usual	No general regulations
Shift work (except night work)	Extra pay; regular rotations unless worker requests otherwise; maximum of 36 to 40 hours/week	No general regulations; double shifts allowed
Night work only	Extra pay; regular rotations unless worker requests otherwise; maximum of 36 to 40 hours/week	No general regulations
Data valid as of	1983[j]	1979[j]

	Ireland	*Israel*
Major source of regulation	Legislation	Legislation and collective agreement
Maximum daily hours	11 (9); RC	8; 7 on the day before holidays and days of rest
Maximum weekly hours	60 (48); maximum of 56 for shift work; RC	47
Rest during the day	0.5 hour/5 hours; RC	No general regulations
Minimum rest between days or shifts	No general regulations; RWC	No general regulations
Minimum weekly rest	No work allowed on Sunday; Saturday short day; shift work exempted; RC	36 uninterrupted hours; 25 for shift workers
Shift work (except night work)	Not allowed unless granted special license (maximum of 48 hours/week averaged over 3 weeks) or required by the nature of the work (maximum of 56 hours/week); minimum of 8 hours between shifts; 15-minute break required 3 to 4 hours into shift; no double shifts	No general regulations; lower minimum weekly rest
Night work only	Prohibited	Maximum of 7 hours/night; RWC
Data valid as of	1989[l] [o]	1986[l]

	Italy	*Jamaica*
Major source of regulation	Legislation	Legislation
Maximum daily hours	8; RC	(8)
Maximum weekly hours	48; shift work can be averaged over a year	40
Rest during the day	No general regulations; RC	No general regulations
Minimum rest between days or shifts	No general regulations; RC	No general regulations
Minimum weekly rest	24 hours, usually on Sundays	No work permitted on Sundays; usually no work on Saturdays
Shift work (except night work)	No general regulations	No general regulations
Night work only	No general regulations; RWC	No general regulations; RWC
Data valid as of	1986[l]	1983[l]

	Japan	*Morocco*
Major source of regulation	Legislation	Legislation
Maximum daily hours	8	(8 to 10, depending on how many days per week worked)
Maximum weekly hours	48, averaged over 4 weeks; RC	48
Rest during the day	45 minutes if work exceeds 6 hours; 1 hour if it exceeds 8	No general regulations; RWC
Minimum rest between days or shifts	No general regulations	No general regulations
Minimum weekly rest	1 day	Uninterrupted 24 hours per week, starting from midnight
Shift work (except night work)	Maximum of 10 hours/day; maximum of 60 hours/week averaged over 4 weeks; RC	Prohibited
Night work only	Extra pay; RWC	No general regulations; RWC
Data valid as of	1986[l]	1985[l]

	Netherlands	*New Zealand*
Major source of regulation	Legislation	Combination of legislation, arbitration, and collective agreement
Maximum daily hours	8.5; RC	8
Maximum weekly hours	48 (40)	40
Rest during the day	If work exceeds 5.5 hours, 0.5 hour within the first 4.5 hours	By collective agreement
Minimum rest between days or shifts	No general provisions	By collective agreement
Minimum weekly rest	No work allowed on Sundays or Saturday afternoons	2 days
Shift work (except night work)	Prohibited; when changing shifts, up to 18-hour shifts allowed	No general regulations
Night work only	Prohibited without special permit; hours must be approved by minister or fulfill either: 1) maximum of 48 hours/week averaged over 3 weeks, maximum of 54 hours in any given week, and maximum of 144 in any given 3-week period; or 2) maximum of 60 hours/week averaged over 4 weeks, and maximum of 56 hours in any given week, and maximum of 192 hours over any given 4-week period	No general regulations; RC
Data valid as of	1986[l]	1986[l]

Table A-1—Regulation of Work, Rest, and Shift Work in 49 Countries—Continued

	Nigeria	*Norway*	*Panama*	*Papua New Guinea*	*Philippines*	*Poland*	*Romania*
Major source of regulation	Legislation	Legislation	Legislation	Legislation, collective agreements, court awards, common rules	Legislation	Legislation	Legislation
Maximum daily hours	No general regulations	8	8; 7 for night shift; 7.5 for mixed shifts	8	8	8 for 6-day week; 9 for 5-day week	8; RWC
Maximum weekly hours	No general regulations	40; 38 for revolving shift work; 36 for continuous shift work	48; 42 for night workers; 45 for mixed workers	44 for rural areas, 42 for urban	48	46 (42)	46; RWC
Rest during the day	1 hour if work exceeds 6 hours	0.5 hour if work exceeds 8 hours	Minimum of 0.5 hour	No general regulations	1 hour/day for meal; short rest breaks required but not specified	No general regulations	0.5 hour plus lunch break
Minimum rest between days or shifts	No general regulations	10 hours; RC	No general regulations	No general regulations		No general regulations	12 uninterrupted hours
Minimum weekly rest	No general regulations	36 hours, 24 of which must be uninterrupted	24 uninterrupted hours	No general regulations	1 day, normally Sundays	No work on Sundays; usually no work on three Saturdays/month	48 uninterrupted hours twice a month; 24 uninterrupted hours on the other weeks; usually this rest falls on Sundays
Shift work (except night work)	No general regulations	See above	After a double shift, worker must receive 12 uninterrupted hours of rest; extra pay	Extra pay	No general regulations	Maximum of 42 hours/week, averaged	Extra pay
Night work only	No general regulations	No general regulations; RC	Maximum of 7 hours/day; maximum of 7.5 hours/day if shift is mixed day-night shift; extra pay; RW	No general regulations	Extra pay (10%); RWC	Extra pay	Maximum of 7 hours without diminution in pay; bonus; extra breaks; RWC
Data valid as of	1984[1]	1986[1]	1978[1]	1986[1]	1979[1]	1986[1]	1986[1]

	South Africa	*South Korea*
Major source of regulation	Legislation	Legislation
Maximum daily hours	9.25 for 5-day week; 8 for 6-day week; 8.5 hours for 6-day week if work does not exceed 5 hours/day	8; RWC
Maximum weekly hours	46	48, but may be averaged over 4 weeks; RWC
Rest during the day	1-hour meal break if work exceeds 5 hours	0.5 hour for every 4 hours
Minimum rest between days or shifts	No general regulations	No general regulations
Minimum weekly rest	No general regulations	1 day
Shift work (except night work)	Maximum of 8 hours/day for continuous shift work; maximum of 9.25 hours/day for 5 shifts/week; maximum of 8 hours/day for 6 shifts/week; if one shift does not exceed 5 hours, maximum of 8.5 hours/day	No general regulations
Night work only	No general regulations	Extra pay; RWC
Data valid as of	1985[j]	1984[j]

	Spain	*Sweden*
Major source of regulation	Legislation	Legislation
Maximum daily hours	9	8
Maximum weekly hours	40	40; may be overridden by collective agreement
Rest during the day	15 minutes/day; RW	No more than 5 hours at a stretch
Minimum rest between days or shifts	12 uninterrupted hours	No general regulations
Minimum weekly rest	Sunday, plus either Saturday afternoon or Monday morning	36 hours
Shift work (except night work)	Maximum of 2 weeks at a time unless worker volunteers	No general regulations
Night work only	Extra pay; RC	Prohibited
Data valid as of	1986[j]	1986[j,l]

	Switzerland	*Tunisia*
Major source of regulation	Legislation	Legislation
Maximum daily hours	No general regulations; RC	9
Maximum weekly hours	45 in industry, office, technical, and sales; 50 for others, including craft and commerce; 52 in shift work (60 for special cases)	48, for nonagricultural work
Rest during the day	15 minutes if work exceeds 5.5 hours; 0.5 hour if it exceeds 7; 1 hour if it exceeds 9	1 hour
Minimum rest between days or shifts	Work permitted from 5 a.m. in summer or 6 a.m. in the winter to 8 p.m.; RW	10 uninterrupted hours
Minimum weekly rest	1 day, usually Sundays	24 uninterrupted hours
Shift work (except night work)	Shifts must rotate every 6 weeks; extra pay; 52 rest days/year of 24 uninterrupted hours each; 9 hours/day averaged over 6 weeks; weekly rest period may be reduced to 20 uninterrupted hours	No general regulations
Night work only	Prohibited; for exceptions, maximum of 9 hours/day averaged over 6 weeks; maximum of 6 weeks at a stretch; RW	No general regulations
Data valid as of	1989[j,o]	1980[j]

Table A-1—Regulation of Work, Rest, and Shift Work in 49 Countries—Continued

	Turkey	*United Kingdom*
Major source of regulation	Legislation, but the Minister of Labor may set rules for night and other shift workers	Collective bargaining, but employers must not require excessive hours or shift patterns likely to lead to ill health or fatigue-induced accidents
Maximum daily hours	7.5 for 6-day workweek, 8.5 for 5-day workweek; maximums of 10.5 and 11.5, respectively	No general regulations; RC
Maximum weekly hours	45	No general regulations; RC
Rest during the day	15 minutes if work exceeds 4 hours; 0.5 hour if it lasts 4-8 hours; 1 hour if it lasts 8 hours or more	No general regulations; RC
Minimum rest between days or shifts	No general regulations	No general regulations
Minimum weekly rest	35 hours, beginning at 1 p.m. on Saturday	No general regulations
Shift work (except night work)	Minimum of 8 hours of rest when changing shifts; maximum of 1 week on night shift at a stretch	No general regulations; RC
Night work only	Maximum of 7.5 hours/night; RWC	No general regulations; RWC
Data valid as of	1986[j]	1989[j,e]

	United States	*Uruguay*
Major source of regulation	State legislation	Legislation; ILO conventions
Maximum daily hours	No general regulations; RC	(8)
Maximum weekly hours	40	48
Rest during the day	No general regulations	No general regulations
Minimum rest between days or shifts	No general regulations	No general regulations
Minimum weekly rest	No general regulations	No work on Sundays, plus another day of rest during week; 36 uninterrupted hours for commercial sector; RWC
Shift work (except night work)	No general regulations	No general regulations
Night work only	No general regulations	No general regulations; RWC
Data valid as of	1986[j]	1980[j]

	U.S.S.R.	*Venezuela*
Major source of regulation	Legislation	Legislation
Maximum daily hours	10 (8)	8
Maximum weekly hours	41; RC	418
Rest during the day	Maximum of 2 hours for each 4 hours worked	0.5 hour; no more than 5 hours of continuous work
Minimum rest between days or shifts	At least twice the number of hours in the last shift worked	No general regulations
Minimum weekly rest	42 uninterrupted hours	1 day
Shift work (except night work)	No double shift; regular rotations, usually in 1-week cycles	No general regulations
Night work only	Extra pay; working hours shortened by 1 hour (not applicable to necessary continuous work)	Extra pay; maximum of 7 hours/day; maximum of 42 hours/week for laborer, 40 for other workers; for mixed work (up to 4 hours of night work), maximums of 7.5 hours/day and 45 hours/week
Data valid as of	1986[j]	1984[j]

	Yugoslavia
Major source of regulation	Legislation; workers' decisions
Maximum daily hours	No general regulations
Maximum weekly hours	42
Rest during the day	1 hour
Minimum rest between days or shifts	Minimum of 12 hours
Minimum weekly rest	24 hours, usually on Sundays
Shift work (except night work)	No general regulations
Night work only	Extra pay; 15 extra vacation days per year
Data valid as of	1986[j]

[a] **Major source of regulation**: the authority behind the regulations, usually legislation or collective bargaining. Legislation means national laws. Collective bargaining means national collective bargaining. National collective bargaining can mean one monolithic agreement between one major employers' association and one major employees' association or a multitude of collective bargains, depending on the job and the area. The common thread is that the bargains are uniform or coordinated enough so that virtually every worker in the nation is protected. The determination of whether there is such uniformity is based on the judgment of the experts and authorities within each country.

[b] **Maximum daily hours**: the maximum number of hours a person can normally work in a day where standard daily hours are routinely fewer, this is noted. Many countries permit averaging of hours over a longer period; where applicable, this is noted in parentheses.

[c] **Maximum weekly hours**: the maximum number of hours a person can normally work in a week; where standard weekly hours are routinely fewer, this is noted in parentheses.

[d] **Rest during the day**: the breaks permitted during the day for relaxation and for meals.

[e] **Minimum rest between days or shifts**: the length of the rest period required between one period of work and the next.

[f] **Minimum weekly rest**: amount of rest required per week.

[g] **Shift work (except night work)**: all regulations regarding shift work, including rotation schedules, pay, hours, and retirement plans.

[h] **Night work only**: all regulations regarding night work.

[i] **Data valid as of**: excludes any legislation enacted after this date.

[j] Data from *International Encyclopedia for Labour Law and Industrial Relations*, R. Blanpain (ed.) (Boston, MA: Kluwer, 1982).

[k] RWC—restrictions on women and children. This means that there are regulations limiting the work of these populations; e.g., they may be permitted to work fewer hours than men or only certain hours.

[l] Data from *Conditions of Work Digest*, vol. 5, No. 2 (Geneva: International Labor Organization, 1986).

[m] RC—restrictions on children; see RWC.

[n] RW—restrictions on women; see RWC.

[o] Data have been verified in 1989 by the relevant ministry or department of the country in question.

NOTE: Only general, national regulations are given; local regulations are omitted, as are industry-specific regulations, such as rules on airline pilots. In addition to the restrictions on women and children (RWC, RC, RW), six exceptions exist in almost every country: One, restrictions on maximum hours, night work, and weekend work do not apply to certain around-the-clock jobs, e.g., nursing, police work, domestic work, and restaurant work. Two, the restrictions do not apply to certain industries where it is not technologically feasible to stop work, e.g., steel, textile, and agriculture during harvest. Three, during catastrophes and emergencies, restrictions are lifted. Four, in a few countries, during periods of labor shortage around Christmas, restrictions on work hours are suspended; for disasters and Christmas overtime, workers are usually entitled to compensatory rest. Five, many countries place special restrictions on pregnant or nursing women over and above the general restrictions on women; e.g., in many countries, nursing mothers receive extra breaks to feed their children. Six, professionals and managers are exempt from maximum work hour restrictions.

SOURCE: Office of Technology Assessment, 1991.

Ireland, Japan, Greece, the U.S.S.R., Hungary, and Turkey. Many countries limit the hours of work in unhealthful or dangerous occupations, including Turkey, Czechoslovakia, Yugoslavia, and Hungary. Six countries prohibit night work by women, and many regulate young people's and women's night work much more stringently than men's.

Hours and Wages

Although most employers voluntarily give night workers higher wages than day workers, many countries have laws to ensure extra pay for night work. These range from 10-percent increases (Germany and the Philippines) to 50-percent increases (Korea), with many countries in between (25 percent in Ecuador, Greece, Ireland, Japan, Portugal, Switzerland, and Spain). In other countries, extra pay for night work is often achieved by collective bargaining. Normally, employers are free to pay the workers more than prescribed by law (6). In the United States, the increase in pay for shift workers is between 7 and 10 percent.

Some governments mandate shorter work hours for night work instead of higher wages, which can have the same effect as raising wages because the workers often receive the same pay for less work. Unlike higher wages, however, shorter hours are directly protective, in that they seek to reduce the strain on the workers. In Argentina, 52 minutes of work at night is considered equivalent to an hour of daytime work. In Brazil, 52.5 minutes is equivalent to 1 hour. These conversions from 52 or 52.5 to 60 minutes are required by law and are used to calculate pay, overtime, and compliance with the maximum working hour restrictions. Some countries arrange shorter hours via collective bargaining (6). In still other countries, such as Bolivia, shorter work hours are written into the constitution (5). In Finland and Sweden, the maximum length of night work is 2 hours shorter than the daytime limit, and in Czechoslovakia it is 2.5 hours shorter. Finally, some countries grant early retirement or longer vacations for night workers instead of, or in addition to, shorter workdays. Australian night workers earn an extra week of vacation every year. Austrian night workers receive 2 to 6 extra vacation days per year, and Yugoslavian employees get 15 extra days (5,6). In both Austria and Luxembourg, night workers are entitled to early retirement by law, and Austrian night workers receive a special pension in addition.

Sometimes extended workdays are unavoidable because of technological constraints. For example, in steel mills using continuous casting techniques, any interruption in the production process damages the machinery. During harvesting season, agricultural workers must work long hours to gather all the crops on time. Mindful of such circumstances, many countries permit some workers, such as shift or seasonal workers, to work longer than normal. These countries include Argentina, Belgium, Austria, Finland, Japan, Switzerland, Bolivia, Colombia, Israel, and India. But employers must limit total work hours so that the average hours are equal to those of the average worker. For example, shift workers in Finland can work a maximum of 40 hours per week, averaged over a

2- to 3-week period. For continuous shift work, they can work a maximum of 90 hours over 3 weeks. Similarly, in Argentina the average hours worked over a 3-week period by a shift worker must conform to the limits imposed for day workers. Thus, leeway in arranging work hours is allowed in some countries, but only within the constraints of maximum total hours.

As described throughout this report, for many shift workers the arrangement of rotations is just as important as the number of hours worked. Physiological and social problems associated with night and shift work are affected considerably by the scheduling of shifts (9). Thus, most workers here and abroad strongly prefer rotating schedules to permanent night shifts (6). In response to this preference, many countries impose limits on the number of consecutive nights a person is permitted to work. Furthermore, most countries (including Finland, Greece, Hungary, Iraq, Norway, Paraguay, Turkey, the U.S.S.R., and Venezuela) encourage rotating schedules, usually on 1-week rotations. Iraq imposes a maximum of 1 month for night work, and Switzerland forbids more than 6 consecutive weeks of night work. Recent research, however, has shown that permanent night shift work may be physically, mentally, and socially better in some situations than rotating shifts and that 1-week rotations seem to be the most disruptive to biological rhythms (9).

Finally, another point of concern is double shifts. Some countries permit double shifts (India, Austria, Germany, the Netherlands, Panama), but more countries prohibit them. Many do so indirectly, by restricting the number of hours that can be worked consecutively, but the U.S.S.R., France, Ireland, Turkey, and Czechoslovakia do so directly. According to recent research, an extra-long break is advisable when shift workers are changing from a night to a day shift (6). On rotation schedules of one week or longer, shift workers build up a sleep debt during the night shift. This debt should be alleviated by extra sleep at the end of the night rotation (6). At present, no country requires this type of extra rest. Also, no country regulates the direction in which shifts rotate (i.e., forward or backward).

Other Concerns

Apart from the issues of pay and hours, shift workers have a host of other concerns. These include obtaining adequate medical supervision, food, sleep, transportation, and entertainment. Shift workers can face health problems from continually operating out of synchrony with their biological rhythms. Factory canteens often close at night, and night workers must endure relatively poor food. Sleep during the day is more likely to be interrupted than sleep at night. Transportation and entertainment schedules are usually designed around standard daytime work schedules.

Only a few countries have provisions for extra medical supervision. The most common form of supervision, where it exists, is a medical examination before a worker engages in shift work. Such supervision is required by law in France and Portugal and by collective agreement in Germany (6).

One characteristic complaint of the shift worker is digestive problems. Often, ulcers can be traced to the quality and availability of food. With rotating shifts, continual variation in meal times disrupts the digestive system. In recognition of this, several countries have adopted special regulations for shift workers' meals. French law stipulates special food arrangements. The U.S.S.R. also requires a free or subsidized meal for its night workers. Many other countries have food arrangements by collective agreement (6).

Another common problem is inadequate sleep. Noise tends to be greater during the day, and sunlight can impede sleep. The continually disturbed circadian rhythms of rotating shift workers make it generally more difficult to fall asleep during the day. As a result, they often sleep less well and for a shorter time than their daytime counterparts. This can lead to drowsiness on the job, stress, and damage to the health of the workers.

France is unique in addressing the problem of the quality and quantity of sleep for night workers, establishing a multiministerial committee which has provided special arrangements for night workers' housing. Not only do night workers get priority in obtaining nationally directed funding for housing, but they also receive 6 percent more money than other workers to soundproof and lightproof their houses. People who soundproof or lightproof their old dwellings can get 50 percent of the expenses back from the government and qualify for special loans to help with the balance (6).

France's multiministerial committee has also taken steps to arrange leisure activities for night workers. Because most recreational and entertainment activities are organized around daytime schedules, many night workers are forced to engage in solitary pursuits for entertainment. Night workers frequently complain about being on the fringe of society and often suffer from isolation, which may play an important role in causing biological and psychological problems. Thus, the French committee has provided for rebroadcasts of certain television programs for night workers. A few other countries have also made arrangements to facilitate leisure activities for shift workers. In other countries, nonstatutory arrangements exist, such as collective agreements for leisure programs and facilities (6).

Public bus and train services often cut back or eliminate operations at night. Getting to and from work after hours can be difficult. Special transportation arrangements usually come from collective agreements, such as those in

Australia and Canada, entitling some categories of female night workers to free transportation between home and the workplace (two provinces in Canada, certain jobs in Australia). In Mauritius and Swaziland, employers must either provide or pay for transportation for all night workers (6).

In summary, the amount and kind of support countries offer their shift workers vary widely. In most cases, hours of work and pay rates are regulated. A few countries have made efforts to extend their services further. In particular, France has adopted extensive policies to alleviate the problems of its night workers, who make up almost one-seventh of its labor force.

Women's Night Work

Restrictions on shift work are protective in nature. They are designed to protect the worker from exposure to unreasonable dangers or strain and to prevent employers from taking advantage of workers. Predictably, then, much of the legislation on shift work applies to women and children, who are traditionally the focus of protective labor legislation. Many countries have stricter labor restrictions on women than men in all aspects of work, including maximum overtime, daily working hours, rest periods, and so on. Most countries also limit young people's work, but these limits are not nearly as controversial as those on women, because most people accept the necessity of protecting young people.

The first national ban on women's night work was passed in England in 1844. Other countries soon followed suit. The bans were prompted by government recognition of and concern about the exploitation of women and children in factories, but they were eventually applied to other areas of work as well. In 1890, the International Congress for the Protection of Workers adopted a resolution against women working at night. In 1906, the Berne Convention met and proposed a ban on women's night work in an industry if the employer had more than 10 workers. Thirteen countries signed the ban. The ILO has had three conventions against industrial night work for women (6).

At one time in the United States, 20 States had laws against women working at night, but by the 1970s all of them had been repealed. In 1924, the Supreme Court upheld the constitutionality of prohibiting women's night work (12), but the Equal Employment Opportunity Commission has decided that such laws are discriminatory under Title VII of the Civil Rights Act (29 CFR 1990 ed. 1604.2(b)(1)).

There were many reasons for placing women under stricter night work regulations than men. Women were thought to need more protection because they were thought to be physically and psychologically weaker than men. They were thought to need protection by law because they were unable to fight for themselves individually. In addition, it was also feared that allowing women to work at night might take them away from their traditional domestic duties, such as rearing children and keeping house. Safety was also cited as a greater concern when women worked at night, especially during the travel to and from work. Increased opportunity for moral degeneracy was even cited as a reason to prevent women from working at night. Sometimes men were afraid that women would take their jobs. In other cases, male workers seem to have been planning to use a ban on women's night work as the first step toward a general ban on night work. All these factors led to the widespread ban on women's work at night (6). In many countries, these conditions still hold and the same arguments are still advanced.

Algeria, Argentina, Austria, Bolivia, Cape Verde, Costa Rica, Czechoslovakia, Ecuador, Egypt, Germany (manual workers), Indonesia, Peru, Philippines, Saudi Arabia, Thailand, Turkey, and Venezuela currently restrict night work by women. Algeria, Argentina, Bolivia, Indonesia, Austria, and many other nations categorically ban women's night work. Some countries, such as Denmark, Norway, and Sweden, ban night work by both male and female workers, but it is much easier for men to obtain exemptions. There are also exceptions to the ban on women's night work. For example, in most countries, managerial workers, including women, are excluded from the ban. In Austria, Ghana, Nigeria, Greece, and other countries, the prohibition on women night workers is suspended for certain seasonal tasks such as harvests. In Austria, Angola, Switzerland, Iraq, and other countries, women are permitted to work at night in emergencies. In Zaire, Saudi Arabia, and other countries, one or more persons in the government are authorized to issue exemptions at their own discretion (6).

Some countries, such as Ethiopia, Singapore, and Chile, prohibit pregnant women from working at night. Germany, Mongolia, and Luxembourg prohibit nursing mothers from working at night. Hungary and Mongolia prohibit mothers with children under the age of 1 from working at night, and Bulgaria extends the ban to the age of 3. In Bulgaria, mothers with a handicapped child or a child between 3 and 6 years old may refuse to work the night shift. In Poland, pregnant women and women with children under 1 year old may refuse night work assignments.

In recent years, attitudes toward women's night work have changed. Recent evidence indicates that women are no more susceptible to physiological or medical harm from night work than men (4), prompting the United Nations to pass a resolution recently calling for equality between the sexes. The ILO has issued a convention on equal pay, and several nations have denounced the ILO's convention prohibiting women from working at night.

The reason for the change in opinion is partly social and partly economic. Many countries are finding it necessary to employ women at night in order to be competitive. The United Kingdom, France, and Luxembourg have all declared that prohibitions on women's night work impair economic efficiency. Some countries that have repealed such prohibitions are Barbados, Canada, Guyana, Ireland, Israel, New Zealand, Sri Lanka, and Surinam (6).

Some parties argue that the proper way to achieve equality is not by lifting the ban on women but extending it to men. Workers' organizations in Finland, France, and Germany have called for extending the night work ban to men. Some workers in Japan, Netherlands, Switzerland, and Britain also demand a prohibition on night work for men. Others argue for the preservation of the status quo. When Sri Lanka was considering abolishing restrictions on women's night work, for example, the Ceylon Mercantile Union argued unsuccessfully for the preservation of the ban because the adverse effects of night work are harsher on women, who also have family responsibilities. In many developing countries, ingrained social and economic conditions make it almost impossible for women to work at night.

In any case, there is almost unanimous agreement that pregnant women should not work at night. In 1978, the ILO Tripartite Advisory Meeting on Night Work unanimously called for the prohibition of pregnant women in night jobs.

Types of Regulations

In countries where regulations exist, they take four basic forms:

- national collective agreements, where a union representing all or most of the workers in a country negotiates the contract with an employer's group, resulting in consistency of working conditions across the nation and fields;
- national government legislations, where the national government sets the rules;
- local collective agreements, where small-scale bargains are struck; and
- local legislation (e.g., State laws in the United States), where smaller bodies than the national government set the standards.

Combinations of the various methods are also used. In some countries, special systems have been set up to resolve labor disputes. In Australia, for example, wages are fixed by government-mandated court arbitration. The most common form of regulation is national legislation, followed by national collective bargaining. Unlike many local regulations, national regulations normally apply to all industries and to all workers; however, certain industries, e.g., transportation, mining, or hotels, are often governed by separate sets of regulations.

The International Labor Organization

The ILO, an agency of the United Nations, is made up of 150 member countries (as of 1989), including the United States. Among other things, it formulates conventions on working conditions (8). Many countries have modeled their protective labor regulations for work hours, children, and women on the ILO conventions. The first convention, enacted in 1919, fixed working hours at 8 hours per day and 48 hours per week. Other conventions address such topics as freedom of association, right to organize and bargain collectively, equal remuneration, asbestos, maritime regulations, medical care, insurance, and discrimination. No country is required to abide by a convention unless its government ratifies it. Once a nation ratifies a convention, however, it is bound by the convention as an international treaty and must report on its implementation to the ILO. The number of countries ratifying the conventions ranges from 0 to 128 (7). Although the ILO has no formal powers of enforcement, it can and does use unfavorable publicity to encourage nations to support the labor standards which they have ratified. The ILO aids in the implementation of labor standards through training, technical assistance, and special programs. This practice has been successful because the ILO enjoys the respect of many countries and its conventions are prominent factors in labor relations. In 1969, the ILO was awarded the Nobel Peace Prize.

Conventions are initiated by questionnaires polling governments' opinions. A preliminary set of proposals is drawn up on the basis of the responses to the questionnaires and introduced at the annual conference. The actual adoption process spans 2 years and also takes place at the conference. Each country sends four delegates to the conference: two government representatives, one employers' representative, and one workers' representative. The conventions are debated and discussed at the first conference and are adopted or rejected at the second. After a convention is adopted, each government is free to ratify or denounce it. A convention may be denounced after 10 years. If a government fails to denounce a convention, that government is bound for another 10 years, and the process is repeated. The ILO can also adopt a purely advisory recommendation which governments are free to follow or ignore.

In 1990, the 77th session of the International Labor Conference adopted convention 171. This convention institutes the first regulations on general night work. All previous night work conventions dealt with women, young persons, or specific industries. The conference also adopted recommendation 178 concerning general night work, along with a protocol which revised convention 89 regarding women's night work.

Convention 171, however, has not yet received the required number of ratifications to be entered into force.

For this reason, several pertinent, older conventions still control night and shift work. Convention number 47, adopted in 1937, reduced the working week to 40 hours. Conventions 14 and 106 provide for weekly rest. In 1979, convention 153 set guidelines on work and rest for road transport workers (7). Employment of workers under the age of 18 in night work is prohibited by conventions 6, 79, and 90 (6). Table A-2 illustrates which countries have ratified various conventions on night and other shift work.

Conventions 4, 41, and 89 prohibit industrial night work for women. Convention 89 is the current version and the one most widely accepted. It prohibits industrial night

Table A-2—International Labor Organization Conventions Related to Night and Other Shift Work and the Countries That Have Ratified Them

Country	ILO convention[a]									
	1	14	20	30	47	79	89	90	106	153
Afghanistan		X			X				X	
Albania										
Algeria		X					X			
Angola	X	X					X		X	
Antigua and Barbuda		X								
Argentina	X	X	D	X		X		X		
Australia					X					
Austria	C			C			X			
Bahamas		X								
Bahrain		X					X			
Bangladesh	X	X					X	X	X	
Barbados								X		
Belgium	X	X					X			
Belize							X			
Benin		X								
Bolivia	X	X	X	X			X	X	X	
Botswana		X								
Brazil		X		X			X		X	
Bulgaria	X	X	X			X			X	
Burkina Faso		X								
Burma	X	X								
Buruni	X	X					X	X		
Byelorussian SSR		X			X	X		X	X	
Cameroon		X					X	X	X	
Canada	X	X								
Cape Verde										
Central African Republic	X									
Chad		X								
Chile	X	X	X	X						
China		X								
Colombia	X	X	X	X					X	
Comoros	X	X					X		X	
Congo		X					X			
Costa Rica	X	X					X	X	X	
Cuba	X	X	X	X		X	X	X	X	
Cyprus							X	X	X	
Czechoslovakia	X	X					X	X		
Democratic Yemen										
Denmark		X							X	
Djibouti	X	X					X		X	
Dominica		X								
Dominican Republic	X					X	X	X	X	
Ecuador									X	X
Egypt	X	X		X			X		X	
El Salvador										
Equatorial Guinea	X	X		X						
Ethiopia										
Fiji										
Finland		X	D	X						
France	C	X					X	X	X	

Table A-2—International Labor Organization Conventions Related to Night and Other Shift Work and the Countries That Have Ratified Them—Continued

Country	ILO convention[a]									
	1	14	20	30	47	79	89	90	106	153
Gabon		X							X	
Germany										
Ghana	X	X		X			X	X	X	
Greece	X	X					X	X	X	
Grenada		X								
Guatemala	X	X		X		X	X	X	X	
Guinea		X					X	X		
Guinea-Bissau	X	X					X		X	
Guyana										
Haiti	X	X		X				X	X	
Honduras		X							X	
Hungary		X								
Iceland										
India	X	X					X	X		
Indonesia									X	
Iran		X							X	
Iraq	X	X		X			X		X	X
Ireland		X	D				D			
Israel	X	X	X	X		X		X	X	
Italy	C	X				X	X	X	X	
Ivory Coast		X								
Jamaica										
Japan										
Jordan									X	
Kampuchea										
Kenya		X								
Kuwait	X			X			X		X	
Laos							X			
Lebanon	X	X		X				X	X	
Lesotho		X					X			
Liberia										
Libya	X	X								
Luxembourg	X	X	X	X		X	X	X		
Madagascar		X					D			
Malawi										
Malaysia							X			
Mali		X								
Malta	X	X					X		X	
Mauritania		X					X	X		
Mauritius		X								
Mexico		X		X				X	X	X
Mongolia										
Morocco		X		X					X	
Mozambique	X	X		X						
Namibia										
Nepal		X								
Netherlands		X					D	X	X	
New Zealand	X	X		X	X		D			
Nicaragua	X	X	D	X						
Niger		X								
Nigeria										
Norway		X		X	X			X		
Pakistan	X	X					X	X	X	
Panama			X	X			X			
Papua New Guinea						X				
Paraguay	X	X		X		X	X	X	X	
Peninsular Malaysia										
Peru	X	X	X					X	X	
Philippines						X	X	X		
Poland		X						X		
Portugal	X	X					X		X	

Country	ILO convention[a] 1	14	20	30	47	79	89	90	106	153
Qatar										
Romania	X	X					X			
Rwanda		X					X			
Sabah										
St. Lucia		X								
San Marino										
Sao Tome and Principe										
Sarawak		X								
Saudi Arabia	X	X		X			X	X	X	
Senegal		X					X			
Seychelles										
Sierra Leone										
Singapore										
Solomon Islands		X								
Somalia										
South Africa							X			
Soviet Union		X			X	X		X	X	
Spain	X	X	X	X		X	X	X	X	X
Sri Lanka							D	X	X	
Sudan										
Surinam									X	
Swaziland		X					X	X		
Sweden		X	D		X					
Switzerland		X					X			X
Syria	X	X		X			X		X	
Tanganyika										
Tanzania		X								
Thailand		X								
Togo		X								
Trinidad and Tobago										
Tunisia		X					X	X	X	
Turkey		X								
Uganda										
Ukranian SSR		X			X	X		X	X	
United Arab Emirates	X							X		
United Kingdom										
United States						X				
Uruguay	X	X		X			D	X	X	
Venezuela	X	X	D							X
Viet Nam		X					X			
Yemen		X								
Yugoslavia		X					X	X	X	
Zaire		X					X			
Zanzibar										
Zambia							X			
Zimbabwe		X								

NOTE: X—Ratified.
C—Ratified conditionally.
D—Denounced.

[a] Convention	Year	Ratifications
1—Hours of work (industry)	1919	49
14—Weekly rest (industry)	1921	104
20—Night work (bakery)	1925	16
30—Hours of work (commerce and offices)	1930	16
47—40-hour week	1935	8
79—Night work of young persons (nonindustrial)	1946	16
89—Night work (women)	1948	62
90—Night work of young persons (industry)	1948	41
106—Weekly rest (commerce and offices)	1957	52
153—Hours of work and rest periods (road transportation)	1979	6

SOURCE: Office of Technology Assessment, 1991.

work by women except in family enterprises, managerial jobs, technical tasks, nonmanual health occupations, and nonmanual welfare work. Other exemptions include when an emergency arises, when night work is necessary to prevent deterioration of materials, and when a government declares a suspension in consultation with employers' and workers' organizations. Night is to be defined by each government, but it must be at least 11 hours long, 7 of which must fall between 10 p.m. and 7 a.m. As of November 1987, 62 countries had ratified convention 89; 73 nations were bound by one or more of the conventions prohibiting women's night work.

The protocol revising the prohibitions on night work for women retains the present restriction but allows it to be overridden by collective bargaining. In addition, the mandatory 11-hour rest period may be varied by legislation, after due consultation with workers' and employers' organizations. Work at least 8 weeks before childbirth, and for a total of 16 weeks before and after childbirth, is prohibited except under special circumstances.

Convention 171's articles are as follows:

- Night work will be any work performed during a period of 7 or more hours, which includes the period from midnight to 5 a.m.
- A night worker will be a person whose job requires night work exceeding an hours limit established by competent authority following consultation with representative organizations of employers and workers or by collective agreements.
- The convention will apply to all workers, male and female, except those in agriculture, stock raising, fishing, maritime transport, and inland navigation.
- A country may exclude certain categories of workers if including them would cause substantial problems, but it must first consult the employers' and workers' organizations.
- A country must report such excluded categories to the ILO, explain the reasons for exclusion, and describe measures taken to progressively extend the convention to the workers concerned.
- Workers should have a right to free medical examination before starting the night work assignment and at periodic intervals during it.
- Workers should receive advice to facilitate their adaptation to night work, especially in regard to sleep, meals, and out-of-work activities.
- Safeguards must be provided for persons who have medical conditions that prevent them from engaging in night work for a given period.
- Measures shall be taken to provide alternatives to night work for pregnant female workers for a period of at least 16 weeks, 8 weeks of which must be provided before the expected date of childbirth.
- The maternity period may be extended for medical reasons.
- During maternity leave, the worker must be protected against dismissal or financial penalization.
- Compensation in pay, benefits, and working time must recognize the nature of night work.
- Appropriate social services should be provided for night workers.
- Adequate first aid and emergency medical transportation must be available.
- The provisions of the convention may be implemented by laws, regulations, collective agreements, work rules, arbitration, court decisions, a combination of these methods, or other appropriate methods.
- If the convention is implemented by laws or regulations, the employers' and workers' organizations should be consulted.

In addition, recommendation 178 adopts the following nonbinding propositions:

- Night work should not exceed 8 hours per 24-hour period.
- Weekly hours for night workers generally should be fewer than, and in any case should not exceed, the weekly hours for day workers doing the same task.
- A rest period of at least 11 hours should be guaranteed between shifts whenever possible.
- Overtime should be avoided for night workers.
- In tasks involving special hazards or heavy mental or physical strain, overtime should be prohibited except in emergencies.
- Double shifts should be prohibited except in emergencies.
- Night workers must be granted rest and meal breaks. The nature of night work's demands must be taken into account when designing the breaks.
- Night workers should be paid appropriately, and men and women should be paid equally for the same work or work of equal value.
- If night workers receive higher wages, those wages should be used to calculate vacation pay, holiday pay, other paid leave, social security contributions, and benefits.
- Where available, consultation with the occupational health services in regard to the consequences of various schedules for night work should be provided to the workers' and employers' representatives.
- Night workers' commuting time should be minimized. This can be achieved by coordinating work hours with public transportation services, providing transport where public transport is unavailable, helping workers obtain means of transport, and building housing near the workplace.
- Employers should compensate night workers for extra transportation expenses involved in traveling between work and home at night.
- Rooms suitable for resting must be provided.

- Facilities for meals must meet the special needs of night workers.
- Night workers should have a place to prepare or heat and eat the food they have brought.
- Where possible, employers should make appropriate food and beverages available to night workers.
- The extent to which night work is performed locally should be considered when establishing nursery facilities.
- Night workers should be considered when public authorities or employers are encouraging recreational, cultural, or sporting activities.
- When composing night crews in shift work, consideration should be given to the needs of older workers, workers with family duties, and workers in training.
- Paid educational leave and training opportunities, where available, should be arranged so that night workers can take part.
- After a certain number of years, night workers should receive priority for openings on the day shift for which they have the necessary qualifications, and any required training for day work should be provided.
- Night workers should have priority for early retirement programs, where available.
- Occupational safety at night should be equal to that during the day.
- Special attention should be given to toxic substances, noise, poor lighting, and high levels of mental or physical strain involved in night work. The effects of these factors should be minimized.
- Night workers who are trade union representatives should have the same rights as their daytime counterparts.
- The workers' representative should be consulted regularly regarding the organization of night work as it relates to personnel and to the undertaking.

Implementation of ILO conventions varies. Most conventions are not self-executing, therefore each government must act to promulgate each convention. The convention on general night work is likely to be implemented in a variety of ways (see the last two points of convention 171).

The United States and the ILO

The United States has not approved many ILO conventions. As of July 1989, it had ratified nine, almost all of which were maritime conventions. In fact, the United States withdrew from the ILO between 1977 and 1980. A combination of factors is responsible for the paucity of ratifications, but one justification has been that the United States already has sufficient protective legislation.

One factor to be considered when dealing with ILO conventions is the expanding multinational role of U.S. companies. In light of this trend, uniform labor standards could be advantageous to American firms (2). However, if the general night work convention passes in its proposed form, the United States is unlikely to approve it. The restriction on pregnant women (article 10) is unacceptably discriminatory in the United States (2), and some of the provisions of the convention appear to be within the jurisdiction of the States, not the Federal Government (11).

Ratification rests ultimately with the U.S. Senate, but the evaluation process is handled by the President's Commission on the ILO, headed by the Secretary of Labor and composed of government, employers', and workers' representatives. Under this commission is the Tripartite Advisory Panel on International Labor Standards, which analyzes legal issues of the conventions and makes recommendations to the committee. The present policy regarding ILO conventions is that they will be ratified only if every Federal and State law is already in compliance with the convention in question (11).

Relevance of Foreign Regulations

A word of caution is in order about comparing data from other countries with U.S. policies. In many countries, the system of worker-employer-government relationships is different from the U.S. system. In Japan, for example, an agreement for limiting work is often based not on hours, but on production (1). In other words, a collective bargain in Japan could focus on the number of cars to be produced rather than the maximum number of hours to be worked. In Australia, wages and hours are set by a system of mandatory court arbitration. In Soviet and Eastern European countries, wages and hours are usually set by the government. Data from foreign countries, therefore, do not always fit into the framework of U.S. labor. Nevertheless, the data are useful because the physiological, psychological, and social problems faced by night workers are similar everywhere, and it may be instructive to examine the ways that other governments have dealt with the issues of shift work.

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Appendix B
Federal Research Activities

Research on biological rhythms in this country has been directed primarily at the basic mechanisms underlying those rhythms. It has produced a marked increase in our understanding of the biology and functions of circadian rhythms over the past two decades, as reviewed in chapter 3. However, little effort has been made to apply these research findings to workplace issues, as reviewed in chapter 5. While it is clear that many of the findings from studies on animals can lead to identification of problems of circadian function in humans, there is a need for research aimed at identifying appropriate interventions to alleviate these problems, which affect the health, safety, family welfare, and productivity of U.S. citizens.

The Federal Government is the principal supporter of research on biological rhythms in this country. Its effort is distributed among various departments, agencies, and institutes, based upon their missions and priorities.

Department of Health and Human Services

National Institutes of Health

The National Institutes of Health (NIH) is the principal Federal agency supporting biomedical research. In fiscal year 1989, NIH funded 150 research projects focused primarily on biological rhythms, according to a search of the NIH's Computer Retrieval of Information on Scientific Projects (CRISP) database. Almost all were competitive grants to investigators in public and private institutions; only five were conducted by the NIH. About 40 percent of the biological rhythm research was supported by two institutes, the National Institute of Child Health and Human Development and the National Institute of Diabetes and Digestive and Kidney Diseases. Most of this research deals with the cyclic production of hormones and their influence upon reproductive functions and energy metabolism. Eight other NIH institutes and divisions funded the remaining 60 percent. Almost all of this research supported by NIH deals with the physiological bases of biological rhythms (primarily circadian rhythms) and their manifestations in endocrine, metabolic, reproductive, or sleep-wake functions. Many of these projects are aimed at delineating the neural circuitry that links the light signal to the biological clock in the hypothalamus (the suprachiasmatic nucleus) and to the neuroendocrine mechanisms which regulate other organ systems. Approximately half of the projects involved human subjects. This research should also lead to further understanding of other problems of circadian dysfunction, such as disturbed sleep, jet lag, and shift work. Only 5 of these 150 projects are directly related to the effects of shift work, with total expenditures of about $250,000. Individual research projects averaged about $112,000, and NIH expenditures on research primarily related to biological rhythms totaled approximately $17 million. This was about 2.5 percent of NIH's total budget of $6.8 billion for fiscal year 1989.

Alcohol, Drug Abuse, and Mental Health Administration

The Alcohol, Drug Abuse, and Mental Health Administration (ADAMHA) is also a major supporter of biomedical research in this country. It had 46 projects on biological rhythms in fiscal year 1989, according to a CRISP search, most of them supported by the National Institute of Mental Health. Much of this research deals with the desynchronization and regulation of biological rhythms in psychiatric states, primarily depression. Goals of studies are not only to delineate the causes of these disturbances, but also to develop effective treatments for them. Other research is directed toward understanding the basic neural structures, processes, and functions of the circadian clock. Such efforts to elucidate the physiological mechanisms controlling normal and disordered biological rhythms can lead to improved diagnosis and treatment of the pathophysiological conditions associated with circadian rhythms dysfunction. ADAMHA funded 39 extramural grants at a cost of about $4.6 million, or about $117,000 per project.

Centers for Disease Control

National Institute for Occupational Safety and Health—The National Institute for Occupational Safety and Health is a component of the Centers for Disease Control. Its mission is to conduct and support research related to issues of occupational health and safety. Circadian rhythm and related shift work research is presently being conducted in one intramural laboratory, with funding of about $100,000. Studies are being conducted on 12-hour work schedules as well as means of promoting adaptation to and coping with shift work (1).

National Science Foundation

The National Science Foundation (NSF) is an independent agency of the Federal Government established to promote and advance science in the United States. Research supported by NSF in the biological and social sciences does not include clinical research, either in human beings or in animal models of disease. Thus, the research on circadian rhythms supported by the NSF is basic research. In fiscal year 1990, NSF supported 24 grants totaling about $1.2 million of the $9.8 million allocated to the biological, behavioral, and social sciences. These projects dealt with fundamental molecular and cellular processes underlying biological rhythms across a number of species. While the results from these studies will add to knowledge of the control of biological and circadian rhythms, no NSF projects directly addressed biological rhythms in the workplace (13).

Department of Veterans Affairs

The Department of Veterans Affairs (VA) supports an intramural research program related to its mission both with its own funds and with funding from other granting agencies. In fiscal year 1989, sleep disorders research received about $800,000 in VA funds and $1.4 million from other granting agencies. Within this program, four projects related to circadian rhythms received about $350,000. Only one of these projects focused directly on the performance deficit associated with continuous operation and strategies for ameliorating it; the other projects dealt primarily with the neural mechanisms of sleep and sleep-related disorders. Total VA support of research in fiscal year 1989 was $220 million (11).

National Transportation Safety Board

The National Transportation Safety Board (NTSB) is an independent Federal accident investigation agency. Its mission is to determine probable causes of transportation accidents and to formulate recommendations to improve transportation safety. It has investigated a number of major transportation accidents in which fatigue, sleepiness, sleep disorders, and circadian factors were involved. The NTSB does not have a research capability, aside from its very important function of gathering accident data and conducting special studies based on its investigative experience, but it does develop agreements with other Federal agencies when research is necessary (4).

Department of Transportation

Federal Highway Administration

The Federal Highway Administration (FHWA) supports research on highway safety in three general areas: safety design, traffic safety research, and traffic systems. The Traffic Systems Division is responsible for human factors research. In fiscal year 1989 FHWA awarded a $1.4-million contract entitled, "Fatigue and Driver Alertness Study." The objectives of this study are to: 1) establish measurable relationships between commercial motor vehicle driver activities and physiological and psychological indicators of fatigue and reduced driver alertness, and 2) identify and evaluate the effectiveness of any alertness-enhancing measures that may legally be used by commercial motor vehicle drivers. In fiscal year 1990, a companion $1.35-million contract, Physiological Measurement of Commercial Motor Vehicle Drivers, was awarded to the Trucking Research Institute (TRI) to complement the project through development and implementation of additional methods for collection and analysis of physiological data from the same group of driver subjects. This contract is being funded jointly by the FHWA and TRI (6).

Federal Aviation Administration

The Federal Aviation Administration's (FAA) Civil Aeromedical Institute conducts two kinds of research to assess the performance of personnel in technical occupations. The first addresses individual performance, identifying factors such as workload and work schedules, equipment design characteristics, and operational stressors that positively and negatively affect it. The second type of research addresses system performance, evaluating the effectiveness and efficiency of agency recruitment, selection, and training programs for employees. Specific research projects currently under way include: 1) identification of the interactive effects of stressors such as age, sleep loss, altitude, alcohol, and fatigue on performance, and 2) analysis of the effects of a 10-hour workday and rotating shift schedules on measures of air traffic controllers' performance and attitudes (14).

The FAA is also engaged in cooperative research efforts with the National Aeronautics and Space Administration. The FAA is providing $450,000 for three studies in fiscal year 1991 examining alertness and controlled napping, long-haul operations, and bunk rest for flight crews (9).

Federal Railroad Administration

The Federal Railroad Administration (FRA) is currently sponsoring research into the effects of work-schedule-related disruptions of sleep and rest patterns on fatigue and job performance. Most locomotive crews work highly irregular and unpredictable schedules, resulting in sleep loss and circadian desynchronization. The Volpe National Transportation Systems Center (VNTSC), a part of the Department of Transportation's Research and Special Project Administration, has been given tasks in two areas related to this problem. The first task is to work with the railroad industry to develop quantitative measures of work schedule irregularity in various groups of workers and to explore new approaches to scheduling in order to reduce problems. The second task is to design and conduct experiments to quantify degradation in train-handling performance and compliance with safety rules caused by sleep loss and circadian desynchronization. In addition, the FRA and VNTSC have an agreement with Transport Canada to study effects of fatigue. Funding for FRA-sponsored projects for fiscal 1991 is approximately $400,000 (16).

U.S. Coast Guard and Maritime Administration

The Maritime Administration (MARAD) and the U.S. Coast Guard are collaborating in sponsoring research into a variety of issues, including scheduling of work and sleep, related to fatigue in the merchant marine and their implications for safety. The VNTSC has recently completed a study of the potential impact on fatigue of reductions in maritime crew size. Results indicate that a major factor in fatigue is the concentration of work hours required during port calls. Ships that make frequent port calls, particularly those with irregular schedules, are likely to cause sleep loss because of disruptions in scheduling. The Coast Guard and MARAD are in the process of planning further research into this problem. Funding for the ship-manning programs, which sponsor the maritime fatigue research, is on the order of $150,000 for fiscal year 1991 (16).

Department of the Interior

Bureau of Mines

For the past 6 years the Human Factors Group within the Safety Research Division of the Bureau of Mines has been committed to research activities on various work schedules in the mining industry. This research has principally been involved with factors that affect adjustment to work schedules and the effects of work schedules on variables such as sleep quality and quantity, eating, and physical and mental exhaustion. This project has received approximately $150,000 per year and is funded through fiscal year 1991 (5).

National Aeronautics and Space Administration

Both the Life Sciences Division, Office of Space Sciences Application, and the Information Sciences and Human Factors Division, Office of Aeronautics, Exploration, and Technology, of the National Aeronautics and Space Administration (NASA) support research. The Life Sciences Division focuses on basic studies of biological mechanisms in animal systems and on the effects that extended time in space vehicles can have on biological rhythms and human physiology. The Information Sciences and Human Factors Division supports research and technology development for aeronautical problems in cockpit crew fatigue, sleep, and circadian rhythms.

As shuttle crews engage in missions longer than a week and planners look forward to missions lasting months, issues of circadian rhythms have emerged as critical to human performance. The Life Sciences Division sponsored a workshop in the summer of 1990 to develop a plan for circadian rhythms research. Concurrently, the application of available knowledge about circadian cycles during transmeridian flights in commercial aircraft has been the subject of applied research and technology at NASA's Ames Research Center.

NASA spent some $2 million on circadian rhythm research in fiscal year 1991. About half was for intramural research and half for support of extramural research. Extramural research proposals are received both as unsolicited applications and as responses to announcements. A recent announcement called for studies on human sleep, fatigue, and performance for missions over 13 days long. Questions of interest include how factors in space flight affect circadian rhythms and how to ameliorate any adverse effects. An example of this research is the feasibility of using bright light exposure to facilitate adaptation of astronauts to their work-rest schedules during extended missions (15).

Over the last 8 years, the Flight Human Factors Branch at Ames Research Center has conducted extensive field studies to examine the issues of fatigue, sleep, and circadian rhythms in flight crews. In some cases this research has been part of a cooperative effort with the FAA. The settings studied have included short and long commercial and military operations, overnight cargo operations, and helicopter operations. This work involved the collection of continuous physiological data; self-assessments of fatigue and mood; and information on sleep timing and quality, food and fluid intake, and the use of medications, alcohol, and tobacco. Funding for aeronautical research in this domain amounted to about $750,000 in fiscal year 1991 (8).

Department of Defense

Department of the Army

U.S. Army Research Institute for the Social and Behavioral Sciences—The Army Research Institute (USARI) supports behavioral research in order to solve personnel-related problems of substantial concern to the Army. As part of a broad agency announcement issued in 1989 and again in 1990, USARI solicited proposals for fundamental research in behavioral science. One area for study was human chronopsychology—specifically, how interactions of chronopsychological variables and characteristics of a task determine performance accuracy and effectiveness. This program continues to be central to USARI's fiscal year 1991 research plans. One extramural project has been started under this program to study cognitive performance in relation to states of arousal and time-of-day variables.

USARI also supports research on the effects of continuous operations upon soldiers' performance. (In continuous operations, the military engagement is continuous but the demands upon the individual are not. This is in contrast to sustained operations, in which the individual has to perform throughout the operation.) Current research focuses upon the ability of soldiers to maintain optimal effectiveness and endurance in chemical defense situations for extended periods. How long can soldiers perform effectively while wearing chemical defense suits or being contained within tanks for up to 72 hours? What work-rest schedules for tank crews would maintain their ability to perform physical and cognitive tasks? Most of this research is conducted as part of field exercises, although there is some contract work, which is expected to amount to about $175,000 in fiscal year 1991 (7).

Medical Research and Development Command—Sleep research in the Medical Research and Development Command is conducted through the Walter Reed Army Institute of Research (WRAIR). Most of this research program is intramural, with only one extramural project now being supported, at a cost of about $1 million in fiscal year 1989. The purpose of the program is to understand the effects of sleep deprivation on performance in situations of brief, fragmented sleep and extended duty hours. Field studies as well as laboratory studies are being conducted and have shown decrements in cognitive functioning (i.e., ability to think, plan, and act) in persons awake for up to 72 hours. Positron emission tomography (PET) techniques are being used to answer questions about brain activity during sleep. Intervention strategies, primarily pharmacological ones, are being investigated. For example, the use of caffeine to counter the effects of 60 hours without sleep and the use of hypnotic drugs to enable a subject to sleep under conditions not conducive to sleep (2,12,17).

The U.S. Army Research Institute of Environmental Medicine (USARIEM) and the U.S. Army Aeromedical Research Laboratory (USAARL) also examine issues related to duty hours. The USARIEM evaluates the effects of various environmental factors on performance and develops appropriate strategies to reduce the adverse effects of such conditions. In addition, USARIEM conducts research and provides information upon which to base Army policy and guidance on biomedical and psychological factors limiting physical and mental performance. Since the work-rest cycle and timing of sleep are critical factors in performance, they are often key variables in research conducted at USARIEM. Laboratory and field studies have examined circadian variations in body temperature, cortisol, and spontaneous motor activity under various conditions related to military operations. Operational models to predict and prevent occupational stress by controlling the work-rest cycle have also been developed and tested. Research and development on appropriate nutritional, pharmacological, and behavioral countermeasures are currently under way. Research in this area was supported at a level of approximately $400,000 for fiscal year 1990, and support for fiscal year 1991 will continue at that level (10). The USAARL studies pilot fatigue and safety issues, including the effects of long flights on helicopter pilots and field assessments of work-rest cycles, activity levels, and amounts of sleep obtained or lost by helicopter crews in various special operations units. Sleep deprivation and sleep stabilization and control experiments are conducted on aircrews who fly at night, to assess pilot flight control performance, cognitive performance, and decisionmaking, as well as the efficacy of drugs in controlling sleep schedules during the day and slightly altering circadian rhythms (10).

Department of the Air Force

Air Force Office of Scientific Research—The Air Force Office of Scientific Research (AFOSR) supports research on the basic neural mechanisms of circadian rhythms. This research is conducted in a variety of experimental systems, from cell cultures to invertebrates to humans. The suprachiasmatic nucleus is of particular interest in much of this research, with questions ranging from the expression of gene-regulating factors and the modulating effects of neuropeptides on these cells in culture, to neurophysiological studies of photic (light) entrainment of this region of the brain in rats, to the effects of light and melatonin on the circadian rhythms of humans. This research is supported by extramural grants and intramural research at the U.S. Air Force's Armstrong Laboratory at Brooks Air Force Base; support totaled about $1.5 million in fiscal year 1990 (3).

Department of the Navy

Office of Naval Research—The Office of Naval Research (ONR) supports programs emphasizing the creation and exploitation of a cumulative base of scientific knowledge from which new technologies can be developed to improve the effectiveness of Navy and Marine Corps personnel. There currently are no projects relevant to sleep or circadian rhythms or their effects on performance (18,20).

Navy Health Research Center—The Navy Health Research Center, in San Diego, is conducting research on sleep and circadian rhythms as they apply to activities and performance of personnel on ships and field maneuvers. These studies are documenting sleep profiles and circadian temperature rhythms during extended work and rest cycles in both laboratory and field situations. They are also investigating the use of pharmacological interventions and naps to improve performance under continuous operations and extended duty. In fiscal year 1989, support of these studies was about $510,000 (19).

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Appendix C

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Appendix D

Acknowledgments

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Appendix E

List of Contractor Documents

For this report, OTA commissioned six reports on various topics related to biological rhythms and shift work. The reports are available from the National Technical Information Service (NTIS) in Springfield, VA. For additional information, call NTIS at (703) 487-4600.

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- "Legal and Regulatory Issues Related to Work Schedules and Hours of Work," B.W. Mintz, 1991 (NTIS No. PB 91215921).

Appendix F

Decade of the Brain

Public Law 101-58, 101st Congress Joint Resolution

Whereas it is estimated that 50 million Americans are affected each year by disorders and disabilities that involve the brain, including the major mental illnesses; inherited and degenerative diseases; stroke; epilepsy; addictive disorders; injury resulting from prenatal events, environmental neurotoxins, and trauma; and speech, language, hearing, and other cognitive disorders;

Whereas it is estimated that treatment, rehabilitation and related costs of disorders and disabilities that affect the brain represents a total economic burden of $305 billion annually;

Whereas the people of the Nation should be aware of the exciting research advances on the brain and of the availability of effective treatment of disorders and disabilities that affect the brain;

Whereas a technological revolution occurring in the brain sciences, resulting in such procedures as positron emission tomography and magnetic resonance imaging, permits clinical researchers to observe the living brain noninvasively and in exquisite detail, to define brain systems that are implicated in specific disorders and disabilities, to study complex neuropeptides and behaviors as well as to begin to learn about the complex structures underlying memory;

Whereas scientific information on the brain is amassing at an enormous rate, and the field of computer and information sciences has reached a level of sophistication sufficient to handle neuroscience data in a manner that would be maximally useful to both basic researchers and clinicians dealing with brain function and dysfunction;

Whereas advances in mathematics, physics, computational science, and brain imaging technologies have made possible the initiation of significant work in imaging brain function and pathology, modeling neural networks, and simulating their dynamic interactions;

Whereas comprehending the reality of the nervous system is still on the frontier of technological innovation, requiring a comprehensive effort to decipher how individual neurons, by their collective action, give rise to human intelligence;

Whereas fundamental discoveries at the molecular and cellular levels of the organization of the brain are clarifying the role of the brain in translating neurophysiologic events into behavior, thought, and emotion;

Whereas molecular biology and molecular genetics have yielded strategies effective in preventing several forms of severe mental retardation and are contributing to promising breakthroughs in the study of inheritable neurological disorders, such as Huntington's disease, and mental disorders, such as affective illnesses;

Whereas the capacity to map the biochemical circuitry of neurotransmitters and neuromodulators will permit the rational design of potent medications possessing minimal adverse effects that will act on the discrete neurochemical deficits associated with such disorders as Parkinson's disease, schizophrenia, and Alzheimer's disease;

Whereas the incidence of neurologic, psychiatric, psychological, and cognitive disorders and disabilities experienced by older persons will increase in the future as the number of older persons increases;

Whereas studies of the brain and central nervous system will contribute not only to the relief of neurologic, psychiatric, psychological, and cognitive disorders, but also to the management of fertility and infertility, cardiovascular disease, infectious and parasitic diseases, developmental disabilities, and immunologic disorders, as well as to an understanding of behavioral factors that underlie the leading preventable causes of death in this Nation;

Whereas the central nervous and immune systems are both signaling systems which serve the entire organism, are direct connections between the nervous and immune system, and whereas studies of the modulatory effects of each system on the other will enhance our understanding of diseases as diverse as the major psychiatric disorders, acquired immune deficiency syndrome, and autoimmune disorders;

Whereas recent discoveries have led to fundamental insights as to why people abuse drugs, how abused drugs affect brain function leading to addiction, and how some of these drugs cause permanent brain damage;

Whereas studies of the brain will contribute to the development of new treatments that will curtail the craving for drugs, break the addictive effects of drugs, prevent the brain-mediated "high" caused by certain abused drugs, and lessen the damage done to the developing minds of babies, who are the innocent victims of drug abuse;

Whereas treatment for persons with head injury, developmental disabilities, speech, hearing, and other cognitive dysfunctions is increasing in availability and effectiveness;

Whereas the study of the brain involves the multidisciplinary efforts of scientists from such diverse areas as physiology, biochemistry, psychology, psychiatry, molecular biology, anatomy, medicine, genetics, and many others working together toward the common goals of better understanding the structure of the brain and how it affects our development, health, and behavior;

Whereas the Nobel Prize for Medicine or Physiology has been awarded to 15 neuroscientists within the past 25 years, an achievement that underscores the excitement and productivity of the study of the brain and central nervous system and its potential for contributing to the health of humanity;

Whereas the people of the Nation should be concerned with research into disorders and disabilities that affect the brain, and should recognize prevention and treatment of such disorders and disabilities as a health priority;

Whereas the declaration of the Decade of the Brain will focus needed government attention on research, treatment, and rehabilitation in this area: Now, therefore, be it *Resolved by the Senate and House of Representatives of the United States of America in Congress Assembled*, that the decade beginning January 1, 1990, hereby is designated the "Decade of the Brain," and the President of the United States is authorized and requested to issue a proclamation calling upon all public officials and the people of the United States to observe such decade with appropriate programs and activities.

Approved July 25, 1989.

Legislative History—H.J. Res. 174 (S.J. Res. 173):
Congressional Record, vol. 135 (1989):

June 29, 1989, considered and passed House
July 13, 1989, considered and passed Senate

Appendix G

Acronyms and Glossary of Terms

Acronyms

AAMC —Association of American Medical Colleges
ACGME —Accreditation Council for Graduate Medical Education
ADAMHA —Alcohol, Drug Abuse, and Mental Health Administration
AFOSR —Air Force Office of Scientific Research
AMA —American Medical Association
BLS —Bureau of Labor Statistics
CMSS —Council of Medical Specialty Societies
CPS —Current Population Survey
CRISP —Computer Retrieval of Information on Scientific Projects
CWW —compressed workweek
DOT —Department of Transportation
EOWEO —every other weekend off
EPI —Eysenck Personality Inventory
FAA —Federal Aviation Administration
FHWA —Federal Highway Administration
FLSA —Fair Labor Standards Act, 128
FRA —Federal Railroad Administration
FREIDA —Fellowship in Residency Electronic Interactive Database Access System
FUDR —5-fluoro-2-deoxyuridine
HSA —Hours of Service Act
LMRA —Labor-Management Relations Act
L.P.N. —licensed practical nurse
MARAD —Maritime Administration
MCSA —Motor Carrier Safety Act
MSHA —Mine Safety and Health Administration
NASA —National Aeronautics and Space Administration
NIH —National Institutes of Health
NIOSH —National Institute for Occupational Safety and Health
NRC —Nuclear Regulatory Commission
NSF —National Science Foundation
NTSB —National Transportation Safety Board
ONR —Office of Naval Research
OSH Act —Occupational Safety and Health Act
OSHA —Occupational Safety and Health Administration
OTA —Office of Technology Assessment
PGY —postgraduate year
POMS —Profile of Mood States
PRC —phase response curve
QES —Quality of Employment Survey
QUALPACS —Quality Patient Care Scale
REM —rapid eye movement
R.N. —registered nurse
RRC —Residency Review Committee
SAD —seasonal affective disorder
SCN —suprachiasmatic nucleus
SWS —slow wave sleep
USAARL —U.S. Army Aeromedical Research Laboratory
USARI —U.S. Army Research Institute
USARIEM —U.S. Army Institute of Environmental Medicine
UV —ultraviolet
VA —Department of Veterans Affairs
VNTSC —Volpe National Transportation Systems Center
WRAIR —Walter Reed Army Institute of Research

Glossary

Advanced sleep phase syndrome: A disorder in which falling asleep and waking occur earlier than usual; it is caused by diminished length and amplitude of the circadian cycle. The syndrome is common among elderly persons. Compare *delayed sleep phase syndrome, non-24-hour sleep-wake disorder.*

Amplitude: As it relates to circadian rhythms, the difference between the maximum or minimum and mean values of a function (e.g., body temperature) during the circadian cycle. Amplitude provides a measure of fluctuation within a cycle.

Attending physician: A physician who has completed all phases of the medical education process and whose job is teaching house staff. Compare *house staff, resident.*

Bargaining in good faith: Deliberation, discussion, or conference concerning the terms of a proposed agreement in which both parties agree not to take any unconscientious advantage of the other, even through technicalities of law. See *collective bargaining.*

Benzodiazepines: A class of hypnotic drugs, including Valium, under investigation for effects on circadian rhythms.

Biological rhythm: Self-sustained, cyclic change in a physiological process or behavioral function of an organism that repeats at regular intervals. See *circadian rhythm, infradian rhythm, ultradian rhythm.*

Biorhythm: One of three postulated cycles that control human behavior and performance; biorhythms have no scientific basis.

Body clock: The internal mechanism of the body that controls biological rhythms. See *circadian pacemaker.*

Bright light: As it relates to circadian rhythms, light with an intensity of at least 2,500 lux, which is equivalent to outdoor light at dawn. Bright light has been shown to shift circadian rhythms and has been used to treat seasonal affective disorder, some sleep disorders, and jet lag.

Chronobiology: The scientific study of the effect of time on living systems, including the study of biological rhythms.

Circadian clock: See *circadian pacemaker*.

Circadian cycle: The 24-hour interval between recurrences of a defined phase of a circadian rhythm. See *circadian rhythm*.

Circadian pacemaker: An internal timekeeping mechanism capable of driving or coordinating circadian rhythms. See *circadian rhythm, suprachiasmatic nucleus*.

Circadian rhythm: A self-sustained biological rhythm which in an organism's natural environment is normally synchronized to a 24-hour period. See *biological rhythm*.

Circadian rhythm desynchronization: See *circadian rhythm disruption*.

Circadian rhythm disruption: Disorganization among an organism's internal cycles or desynchrony between self-generated rhythms and the 24-hour cycle in the environment.

Clockwise shift rotation: A work schedule in which the shifts move forward, from day to evening to night. See *rotating shift*; compare *counterclockwise shift rotation*.

Collective bargaining: A procedure whereby an employer and accredited representatives of employees bargain in good faith concerning wages, hours, and other conditions of employment. See *bargaining in good faith*.

Combat operations: Direct involvement in fighting. Compare *combat support*.

Combat support: Provision of supply, communications, or medical aid to fighting units. Compare *combat operations*.

Common carrier: A transportation system that undertakes to carry all persons or goods as long as there is room and there is no legal reason for refusal.

Compressed workweek: A schedule in which employees work approximately 40 hours in fewer than 5 days.

Condition I Battle Readiness: The naval equivalent of sustained operations; all systems on board a ship are manned and operating, and no routine maintenance is conducted. See *sustained operations*.

Condition II Battle Readiness: In the Navy, required operational systems on board a ship are continuously manned and operating, and only essential preventive maintenance and support functions are carried out.

Continuous operations: A military situation requiring around-the-clock manpower but not extended duty hours for individuals. Compare *sustained operations*; see *extended duty hours*.

Cortisol: A steroid hormone secreted by humans; cortisol secretion exhibits a circadian rhythm and is used as a marker for the body's pacemaker.

Counterclockwise shift rotation: A work schedule in which the shifts move backward, from night to evening to day. See *rotating shift*; compare *clockwise shift rotation*.

Current Population Survey: A survey of 55,000 to 60,000 sample households conducted monthly by the Bureau of the Census for the Bureau of Labor Statistics. Supplements to the survey have incorporated questions on shift work.

Day shift: As defined in Current Population Surveys, a period of work in which half or more of the hours worked are between 8 a.m. and 4 p.m.

Delayed sleep phase syndrome: Abnormal delay of the timing of sleep onset and waking, possibly caused by either an abnormally long circadian cycle or a diminished responsiveness to environmental cues. The disorder is most common among teenagers and young adults. Compare *advanced sleep phase syndrome, non-24-hour sleep-wake disorder*.

Deployment: Movement of a military unit to a strategically important location. Deployment can be routine (planned and scheduled well in advance) or surge (done on short notice).

Diurnal: Being active during the day.

Double shift: Two consecutive shifts worked in one 24-hour period.

Entraining agent: A factor that synchronizes an organism's biological rhythms to the outside world; for example, the light-dark cycle is an entraining agent for circadian rhythms.

Environmental cue: A signal from outside an organism that prompts it to some action.

Evening person: A general term used to describe an individual who has difficulty waking up, is able to sleep late in the morning, and finds it difficult to fall asleep at night. Compare *morning person*.

Evening shift: As defined by the Current Population Survey, a period of work in which half or more of the hours worked are between 4 p.m. and midnight.

Extended duty hours: Long periods of work (usually over 12 hours) that cause a worker to get less than usual or no sleep.

Fatigue: Weariness caused by physical and mental exertion.

Field study: In this report, an investigation in which a researcher observes workers in their actual work environment. Compare *laboratory study, survey study*.

Fixed shift: A work schedule in which the hours of work remain the same from day to day. Compare *rotating shift, irregular shift*.

Flextime: A system in which starting and stopping hours of work are determined by the individual worker, with a required number of total hours specified by the employer. Usually there is a daily core period when all workers must be present.

Free-running rhythm: Circadian rhythm operating in the absence of environmental cues; such rhythms may be 20 to 28 hours in length. Under free-running conditions, the human body clock has a circadian rhythm of about 25 hours.

Full-time employment: A job consisting of 35 or more hours of work per week. Compare *part-time employment, shortened workweek.*

General quarters: In the Navy, high-alert or combat conditions at sea. See *Condition I Battle Readiness.*

Graduate Medical Education: Formal medical education, including substantial clinical experience, beyond the M.D. degree. See *residency, resident.*

House officer: See *house staff.*

House staff: Intern, resident physician, or fellow at a teaching hospital. See *resident.*

Infradian rhythm: A biological rhythm with a cycle of more than 24 hours; for example, the human menstrual cycle. See *biological rhythm*; compare *ultradian rhythm.*

Intern: A first-year resident physician. See *resident.*

Internal clock: See *circadian pacemaker.*

Internal desynchronization: Loss of synchronization among rhythms within a single organism.

Irregular shift: A work schedule that is variable and erratic. Compare *fixed shift, rotating shift.*

Jet lag: The malaise associated with travel across time zones; it results from conflict between the traveler's internal clock and the external rhythms in the new time zone.

Laboratory study: In this report, an investigation in which the researcher attempts to simulate the workplace in a controlled environment. Compare *field study, survey study.*

Longitudinal study: Analysis of a function in the same experimental subjects over a period of time; especially useful in determining effects that vary widely among individuals.

Maximum allowable flight duty period: The maximum number of hours an Air Force crew can fly in a certain type of aircraft in a 24-hour period.

Melatonin: A hormone produced by the pineal gland, which is present in many animals, including humans. Melatonin secretion is circadian, and production is readily inhibited by light. Melatonin is being investigated as a possible circadian entraining agent in humans. See *entraining agent.*

Microsleep: Brief episode of sleep experienced by a person who is so tired that he or she cannot resist sleep.

Moonlighting: Holding more than one job.

Morning person: A general term used to describe an individual who wakes up easily, has difficulty sleeping late, and falls asleep quickly at night. Compare *evening person.*

Neuron: A nerve cell, the basic functional unit of the nervous system.

Neurotransmitter: Specialized chemical messenger synthesized and released by neurons to communicate with other nerve cells.

Night float: A shift of physicians sent in at approximately 10 p.m. to relieve residents who have worked all day and evening.

Night shift: As defined in the Current Population Survey, a period of work in which half or more of the hours worked are between midnight and 8 a.m.

Night shift paralysis: A rare condition marked by short-term paralysis, usually lasting about 2 minutes, during which individuals are aware of their surroundings but are unable to move; it is associated with extreme sleep deprivation.

Nocturnal: Being active at night.

Nonflight support: Airfield operations, aircraft repair, communications, and other activities in support of Air Force flight units. Compare *tactical forces, transport forces.*

Non-REM sleep: The four stages of sleep during which the sleeper does not experience rapid eye movement (REM) sleep. See *slow wave sleep, rapid eye movement (REM) sleep.*

Nonstandard work schedule: See *shift work.*

Non-24-hour sleep-wake disorder: The condition of going to sleep and waking up at progressively later times, possibly caused by the inability to perceive light-dark cycles. The disorder appears to be prevalent among blind persons. Compare *advanced sleep phase syndrome, delayed sleep phase syndrome.*

Notice: Information, advice, or written warning intended to notify a person of some proceeding in which his or her interests are involved or informing him or her of some fact that it is his or her right to know and that is the duty of the notifying party to communicate.

Opposed landing: In the Marines, coming ashore against armed opposition; opposed landings involve a very intense period of sustained operations, changing to continuous operations. See *continuous operations, sustained operations.*

Overtime: Time worked at one job in excess of 40 hours per week. Overtime may be required or voluntary.

Part-time employment: A job consisting of fewer than 35 hours of work per week. Compare *full-time employment, shortened workweek, shared time.*

Per gene: A hereditary unit in the fruit fly (*Drosophila melanogaster*) that appears to regulate the organism's circadian rhythms.

Phase response curve: Direction and amount of shifting of an organism's circadian rhythms plotted in response to an environmental cue, such as light. See *phase shift.*

Phase shift: The resetting of an organism's internal clock in response to an entraining agent. The organism's circadian rhythms may be advanced, delayed, or not shifted at all, depending on the timing of exposure. See *entraining agent*.

Pineal gland: A small structure in the brain that produces the hormone melatonin. It is responsive to light and in some species, such as birds, it is the circadian pacemaker.

Rapid eye movement (REM) sleep: Stage of sleep during which the eyes move rapidly, brain activity resembles that observed during wakefulness, heart rate and respiration increase and become erratic, and vivid dreams are frequent. REM sleep alternates with non-REM sleep in cycles lasting 90 to 100 minutes. Compare *slow wave sleep*.

Registered nurse (R.N.): A person who has received a baccalaureate degree in nursing.

Reinforcement: Sending more personnel and equipment to units already deployed. See *deployment*.

Relocation: Transporting a military unit to another location. Compare *deployment*.

Residency: Training program in a medical or surgical specialty for postgraduate M.D.s. Residencies generally last from 3 to 7 years, depending on the specialty. See *graduate medical education*.

Resident, resident physician: A postgraduate (post-M.D.) medical trainee in a medical or surgical specialty.

Rotating shift: Work in which the hours change regularly, for example from a day to an evening to a night shift. Rotation may be rapid (e.g., 3 days), mid length (e.g., 1 week), or long (e.g., 4 weeks); it may proceed forward, as noted above, or backward (day to night to evening). Compare *fixed shift, irregular shift*.

Routine operations: See *continuous operations*.

Rulemaking: The procedure that allows administrative government agencies to promulgate rules to implement, interpret, or prescribe law or policy, or to describe the organization, procedure, or practice requirements of an agency.

Seasonal affective disorder (SAD): Recurring autumn or winter depression that may be helped by treatment with bright light. Although SAD has not been proved to be a circadian rhythm disorder, it has been hypothesized that changes in circadian rhythms cause the disorder.

Shared time: A work schedule in which two persons share one full-time job.

Shift maladaptation syndrome: A combination of ailments arising from the inability of some workers to adjust to long-term shift work.

Shift work: As used in this report, any nonstandard work schedule (including evening or night shifts, rotating shifts, split shifts, and extended duty hours) in which most of the hours worked are outside the period between 8 a.m. and 4 p.m. See *day shift, evening shift, night shift, rotating shift, split shift, extended duty hours*.

Shift worker: A person who works a nonstandard schedule. See *shift work*.

Shortened workweek: A schedule of full-time employment that entails 35 or fewer hours of work per week.

Sleep debt: The state of chronic fatigue and sleepiness that results from the lack of sufficient sleep or disrupted sleep. See *fatigue, sleep deprivation*.

Sleep deprivation: Lack of sufficient sleep. Compare *fatigue*.

Slow wave sleep: The stages of sleep during which the eyes do not move, heart rate and respiration are slow and steady, muscles show little movement, and dreams are infrequent. Compare *rapid eye movement (REM) sleep*.

Special operations: Military operations, such as search and rescue missions and counterterrorism activities, which take place as the need arises, are often classified, and often require the rapid deployment of personnel.

Split shift: A schedule of full-time work in which a period of work is followed by a break and then another period of work.

Standard work schedule: See *day shift*.

Standing watch: In the Navy, working a shift. See *watch*.

Strategic forces: Air Force units that man nuclear bombers and missile silos.

Stressor: A source of stress; as used in this report, disruption of circadian rhythms, fatigue and disruption of sleep, and social and domestic disturbances caused by shift work.

Subjective day: The portion of an organism's internal cycle that normally occurs during the day.

Subjective night: The portion of an organism's internal cycle that normally occurs during the night.

Suprachiasmatic nucleus: A region of the brain of mammals that acts as an organism's primary circadian pacemaker, controlling or coordinating its circadian rhythms. See *circadian pacemaker*.

Surge operations: Military activities carried out under conditions requiring speed. See *sustained operations*.

Survey study: In this report, an investigation in which the researcher asks the worker questions and elicits answers, usually in one or two interviews or classroomlike sessions. Survey studies are often conducted before and after an intervention in order to gauge its impact. Compare *field study, laboratory study*.

Sustained operations: A military situation requiring individuals to work extended duty hours, i.e., longer than 12 hours. Combat and high-alert operations are generally sustained. Compare *continuous operations*; see *extended duty hours*.

Tactical forces: Air Force units that engage in combat and often support land warfare. Compare *transport forces*.

Transmeridian flight: Travel across time zones. See *jet lag*.

Transport forces: Air Force units that fly personnel and materiel from location to location. Compare *tactical forces.*

Ultradian rhythm: A biological rhythm with a cycle of less that 24 hours; human sleep cycles and the release of some hormones are examples. See *biological rhythm*; compare *infradian rhythm.*

Watch: In the Navy, a work shift. Watches are frequently scheduled on a rotating basis. See *rotating shift.*

Weekend shift: A work schedule in which a separate work force is used to work 12 hours per day, 2 days per week.

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